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CHAMPAIGN, MAY, 1890.

BULLETIN NO. 9.

MILK AND BUTTER TESTS.

Composition of Milk.

In this bulletin, Dr. A. G. Manns, until January 1, 1890, assistant chemist of this Station, has reported the results of a large number of tests of milk made by him. The primary object of these tests was the comparison of different methods of determining the value of milk, as indicated by the percentage of fat contained in it. The work thus done shows that the method devised by Mr. F. G. Short is reasonably accurate, provided the tubes necessary in its use have been properly prepared and correctly graduated. Presumably there is less danger of variation in the tubes as now made and sold, than when they were first placed on the market, as the manufacturers probably now use greater care in the graduation. It would be well, however, as sets are purchased, to test them with milk of the same composition before using them to determine the differences in different samples.

Aside from any value this work may have in helping to show the comparative desirability of different methods of determining the fat in milk, it well illustrates the importance of using some accurate method for such determination where milk is bought and sold. Thus, the milk furnished by one patron of the factory at Malta showed 3.07 per cent. of fat; that of another, furnished the same day, 4.75 per cent. In a still more striking manner, this work illustrates the importance of testing the milk of individual cows in a herd; for the variation in the value of the milk of different cows may be greater than in the milk from different herds. The larger the number of cows, the more nearly, probably, will the milk approach the average composition. Thus, while there was at Malta, a difference of 1.68 per cent. in the fat in the milk from two herds, the next

greatest variation was 1.15 per cent.; and in but two other herds, out of a total of 60, was the variation as much as .8 of a per cent. At the DeKalb and Shabbona factories, where the samples were taken from mixed milk from three to a half dozen herds, the greatest variation in fat in any two lots was .9 per cent. in the one case and .57 per cent. in the other. On the other hand, the milk of one pair of the 11 cows tested in one herd showed a difference of 1.8 per cent.; of another pair, 1.4. The milk of two of the 16 cows tested in another herd showed a difference of 1.5 per cent. The average percentage of fat in the milk of four of these cows was 4.48; that of four others 3.53.

The average per cent. of fat found June 17, 1889, by Dr. Manns, using Short's method, in the milk furnished by 63 patrons of the factory at DeKalb was 3.83; June 24th, in the milk furnished by 60 patrons of the factory at Malta, 3.70; July 3d, in the milk furnished by 61 patrons of the factory at Shabbona, 3.66; and the average of fat as shown by the 101 tests made on the three days named in the 35,017 lb. of milk furnished by the 184 patrons of the three factories, was 3.73 per cent.

A more striking illustration of the difference in milk of cows in the same herd, under like conditions, is found in the report of a test made in March, 1890, by Mr. H. B. Gurler, of DeKalb, whose herd, it may be safely assumed, has been selected and bred with more than average intelligence. The milk of 64 of his cows was tested by Short's method. The average per cent. of fat found was 4.21; the highest, 5.85; the lowest, 2.75—a variation of 3.10 per cent. The average of ten cows was 5.41; of ten others, 3.2. Dividing the herd into four equal lots, the average of one lot of 16 was 5.18; of another lot of same number, 3.38.

The difference between the average for this herd (4.21) and that shown above for the 184 herds contributing to the three factories (3.73), is due in part to the character of the food, and to the season of the year.

In the use of Short's test at his creamery at Malta, Mr. Gurler reports, March, 1890: "The last test of patrons ranged from 3.55 lb. fat per 100 lb. milk, to 4.90 lb., very few being under 3.75, and few over 4.25."

Differences found in the Composition of Milk from Cows of Different Breeds. There are well-known differences in the average per cent. of fat in the milk of cows of different breeds. The length of the time since calving, and the condition of the cow, affect the percentage of fat in the milk; but in this case, as in many others, it was clearly shown that there are marked differences in the milk of cows of like breeding and under like conditions.

At the American Fat Stock and Dairy Show, held at Chicago in November, 1889, eight cows competed for prizes to be awarded those giving the greatest quantity of butter fat in milk given in one day. Two Ayrshires, three Holsteins, and three Jerseys competed. The milk was analyzed by Dr. Manns, from whose report the following results are taken:

TABLE SHOWING RESULTS OF MILK TESTS OF COWS OF DIFFERENT BREEDS.

No.	Name.	Breed.	Total milk, Lb.	oz.	Butter fat, oz.	Per cent. butt'r fat	Total s'l'ds, oz.	Per cent. total solids.
5	Spotty G	Ayrshire	32	9½	21.54	4.13	64.77	12.42
6	Young Ellen	Ayrshire	29	1½	18.39	3.95	58.42	12.55
1	May Overton	Holstein	65	7	36.12	3.45	120.02	11.48
7	Mollie Anderson	Holstein	16	9½	9.59	3.61	34.33	12.93
8	Schulling	Holstein	57	13	22.66	2.45	91.21	9.86
2	Marea	Jersey	24	14½	21.24	5.33	56.03	14.06
3	Helen of Oxford 3d	Jersey	13	14	13 54	6.10	34.34	15.47
9	Dot Bloomfield	Jersey	20	2½	14.03	4.35	44.47	13.79

"Entry 1. First premium awarded to May Overton; exhibited by F. C. Stevens, of Attica, N. Y.

"Entry 8. Second premium awarded to Schulling; exhibited by Stevenson Bros., Bulger, Pa.

"Entry 5. Third premium awarded to Spotty G 4900; exhibited by John Stewart & Son, Elburn, Ill."

The precentage of fat in the milk of the three Holstein cows averaged 3.17 with a difference of 1.00; of the Ayrshires, 4.04 with a difference of only .18; of the Jerseys, 5.26 with a difference of 1.75 per cent. between highest and lowest; the extreme difference being 3.65 per cent. The milk of one of the Holstein cows was phenomenally low in per cent. of both fat and total solids, although the large yield of milk made the total amount of fat greater than that produced by any other of the lot except one. It will be noticed that excluding the milk of this cow, which was reported to have been sick for some days preceding the test, the difference of the solids other than fat in the milk of any two of the cows, did not exceed 1.41 per cent., illustrating the important fact that the percentage of fat in milk is much more variable than that of any or all other solids found in it.

COMPOSITION OF BUTTER.

Chemical analysis cannot determine with certainty the comparative excellence of two samples of butter. The texture, color, and even the flavor are not mainly dependent on the percentage of fat, water, and salt. The quality of salt used and the uniformity of its distribution may have more effect on the palatability of the butter than the quantity used. Different markets have different standards, especially as to color and salting. There is, however, much of interest in determining the composition of what is considered good butter in American markets.

The following report of the committee of the Association of American Agricultural Colleges and Experiment Stations, gives the results of the analysis by chemists of recognized ability of a series of samples of butter which had taken first prizes at the only dairy show with a claim to a national character held in the United States last year. As a part of the work was done at this Station, the report may appropriately be inserted here.

"*Composition of American Prize Butter.* By coöperation of the Illinois State Board of Agriculture and the Association of American Agricultural Colleges and Experiment Stations, five samples were taken by Drs. Babcock and Manns, chemists of the Wisconsin and Illinois Experiment Stations, from each of nine lots of butter to which first prizes had been awarded in as many classes at the American Dairy Show, held in Chicago in November, 1889, under the auspices of the Illinois State Board of Agriculture. A set of these samples was analyzed by each of the following chemists: Dr. H. W. Wiley, of U. S. Dep't of Agriculture; Dr. E. H. Jenkins, of the Connecticut Experiment Station; Dr. A. G. Manns, of the Illinois Experiment Station; Professor M. A. Scovell, of the Kentucky Experiment Station; and Dr. S. M. Babcock, of the Wisconsin Experiment Station, except that an accident prevented the analysis by Dr. Babcock of the sample from lot No. 8.

"In the table following are given the names and addresses of the exhibitors; the prize taken by each lot, and the rating of each by the awarding committee on the scale of points adopted; the average of the analyses of the five samples from each lot; and the general average of the forty-four analyses of the nine lots by the five chemists.

TABLE SHOWING RATINGS FOR AWARD AND AVERAGES OF ANALYSES OF BUTTERS TAKING PREMIUMS AT CHICAGO, NOVEMBER, 1889.

No.	Exhibitor.	Address.	Description of Samples.
1	Wm. H. Taylor..	Davis Junction, Ill.	Sw'pstakes—Creamery butter, gathered cream
2	I. F. Laing.....	Chicago.....	Sweepstakes—Creamery butter, whole milk.
3	A. B. Spencer....	Rockport, Ohio ...	Sweepstakes—Dairy butter.
4	L. McDonough..	Davis Junction, Ill.	Sweepstakes—Butter from a grade cow.
5	N. L. Smith....	Lindenville, Ohio..	First Prize—Butter from a Jersey cow.
6	P.L. Yonker.....	Hampton, Iowa....	First Prize—Butter from a Shorthorn cow.
7	A. B. Spencer....	Rockport, Ohio....	First Prize—Butter from an Ayrshire cow.
8	John Hudson....	Moweaqua, Ill.....	First Prize—Butter from a Devon cow.
9	R. Hawkey	Belvidere, Ill.....	First Prize—Butter from a Holstein cow.

	* Rating for premiums.					Averages of Analyses.			
	Flavor.	Grain.	Color.	Salting.	Total.	Fat.	Water.	† Ash.	Curd.
1	43	28.5	14.5	10	96	85.41	9.99	3.58	1.01
2	42	29	13.5	9.5	94	82.66	12.19	3.93	1.21
3	40	29	14	10	93	86.53	8.49	4.12	0.86
4	42	29	14.5	10	95 5	85.96	9.71	3.29	1.03
5	39.5	29	14	8.5	91	88.08	8.99	2.13	0.79
6	41.5	27.5	13.5	8.5	91	84.79	12.07	1.79	1.34
7	40.5	28.5	14	10	93	86.53	9.53	3.32	0.81
8	36.5	28	14	8.5	87	86.20	10.78	2.29	0.72
9	40	29	13.5	10	92.5	85.53	10.56	3.03	0.88
	Average, 40.55	28.6	13.96	9.44	92.5	85.74	10.23	3.05	0.96

* The standard of the scale of points in a total of 100 was—Flavor, 45; grain, 30; color, 15; salting, 10.

† Chiefly salt.

"The scores of the judges show that, in their judgment, the butter analyzed was good, but not exceptionally excellent, from the commercial standpoint, for the Chicago market. As these packages had stood in the exhibition room for about ten days when the samples were taken, it is possible that some of the water of the freshly packed butter had been lost through drying; and the percentage of water in these samples may be assumed to be near the minimum for standard market butter. Otherwise the analyses probably fairly indicate the average composition of such butter. Neither flavor, grain, nor color of butter is necessarily dependent on the chemical composition, and the rating as to salt may depend more on the quality of the salt and the evenness of distribution than on the percentage found.

"The variation in the fat in these nine lots is less than 5.5 per cent. So far as appears from these analyses, the percentage of fat in butter depends on the thoroughness with which the water and buttermilk are extracted, and the quantity of salt allowed to remain, and not on the breed of cows nor the mode of manufacture. The lot with highest rating by the scale of points had a little less than the average per cent. of fat. That which stood lowest had a little more than the average per cent. of fat. The average per cent. of salt is not quite half that often put into American butter. The three lots which were rated lowest as to salting and which stood lowest in total rating, each had less than the average of salt.

"G. E. MORROW,
"W. A. HENRY,
"H. P. ARMSBY,
} *Committee.*"

Composition of Creamery Butter from Connecticut. The following is the average of several analyses by E. H. Farrington, assistant chemist of this Station, of a sample of creamery butter made in Connecticut, and forwarded to the Station by Dr. E. H. Jenkins, of the Connecticut Experiment Station: Fat, 80.75; water, 12.86; curd, 1.32; ash, 5.03 per cent. It will be noticed that this sample had less fat, slightly more water, and considerably more salt than any one of the prize butters referred to in the report above.

Butter Made at this Station. In the work done by Dr. Manns and reported in this bulletin, it was not necessary to make complete analyses of butter. The water was determined in 36 lots of butter made at the Station, Excluding two lots made from spoiled cream, the highest per cent. of water in 34 lots of unsalted butter was 17.12; the lowest, 12.79; the average, 14.71.

GEORGE E. MORROW, A. M., *Agriculturist.*

MILK TESTS.

The system of paying for milk received at creameries, irrespective of its quality, has given rise to numerous discussions as to the practicability of using simple methods for the estimation of fat in milk, as a means of establishing a true basis for its valuation. Such tests, in order to be practicable, must have the requisites of simplicity in manipulation and accuracy. Cream tubes would be invaluable, were the results obtained trustworthy. But the per cent. of fat in cream varies with the temperature of setting and the richness of the milk; and the volume is also directly influenced by the condition of the casein in the milk at the time of setting. Carefully conducted experiments have shown that samples of milk containing like percentages of fat will show large variations in per cent. of cream on standing in the cream tubes.

Other methods, recommending themselves on account of the extreme simplicity of the manipulation, are those based on the optical examination, as with the lactoscope or the pioscope. All optical methods are inaccurate, because the opacity of milk is partly due to the casein; and,

while it is true that the degree of opacity increases regularly with the quantity of fat held in suspension, still it is subject to modification by the variable size of the fat globules. Of two samples of milk containing the same percentage of fat, the one in which the fat globules are smallest will appear to be the richer when examined with the lactoscope.

Short's Test.

The following work, conducted at DeKalb, Malta, and Shabbona, was undertaken by the Station with the object of gathering information in regard to the application of Short's test to the daily work of the creamery. Incidentally, the lactoscope was tested in comparison with the gravimetric and the Short methods.

Two sets of testing flasks, such as are used in the Short test, were examined. The first set had been purchased some time previous to the present work and the flasks exhibited wide variations in the diameters of the contracted portions of the tubes. Sixteen of the flasks had necks of uniform diameter, while in 18 others the differences were sufficient to make a difference of from 1. per cent. to 1.45 per cent. in the results read from the scale. The extreme difference in cubic contents, for equal lengths of the contracted part of the tube, where the fat would be measured, amounted to 33 per cent. of the capacity of that portion of the tubes. These flasks were absolutely worthless, giving misleading, irregular results.

In the second set, and it might be added in others purchased since, the extreme difference in the caliber of the necks made a difference of .3 per cent. in the analytical results obtained. No difficulty has been experienced lately in purchasing well made tubes. However, one should carefully avoid buying from irresponsible parties, for it is of prime importance that the tubes and the scale be accurate.

The Lactoscope.

In order to familiarize ourselves with the instrument at our disposal, a number of tests were made and the results obtained were compared with those found in the gravimetric method. The results soon pointed out a deficiency in the method which, no doubt, everybody who has used the lactoscope will recognize. By following the printed directions for reading the per cent., the results will vary with the person making the test. It was found that the lines on the scale were distinctly visible to some, while others could not see them until a further comparatively larger quantity of water had been added. This defect could be remedied by using a second scale immersed in a milky fluid which could be used as a standard for comparison. The test scale would show the lines as they should be seen in the lactoscope when sufficient water had been added. Such a test scale would be far more serviceable than the printed directions accompanying the instrument. The first readings taken were, on an average, .75 per cent. lower than they should have been, and it required some practice with milk samples in which the per cent. of fat was known before the eye

could distinguish the proper point where the further addition of water should be discontinued.

The lactoscope proved very efficient as a simple means of testing the milk of individual cows in a herd.

The following results were obtained at two dairys visited:

TABLE SHOWING TESTS WITH THE LACTOSCOPE.

First.			Second.		
No.	Pounds of milk.	Per cent. of fat.	No.	Pounds of milk.	Per cent. of fat.
1	5.25	4.55	1	14	4.35
2	6.25	4	2	9.5	4.10
3	1	4.15	3	6	4.10
4	2	4.25	4	7.75	3.35
5	4	4.25	5	16.5	3.35
6	5	4.30	6	6.25	4.50
7	1.5	4.10	7	7	4.35
8	8.5	2.85	8	7.5	4.10
9	1.25	2.75	9	3.5	4.85
10	5.25	4.10	10	8	4.10
11	1.25	3.60	11	5	3.60
			12	8.5	4.35
	Average.	3.90	13	3	4.25
			14	5.5	4.10
			15	4	4.25
			16	6	3.85
				Average.	4.10

COMPARATIVE TESTS.

Each sample of milk was analyzed by the gravimetric and the Short methods and was also tested with the lactoscope. The first table comprises a few of a large series of results obtained by testing milk with the lactoscope and by the Short test. The results of the Short test are used as the basis for comparison. The gravimetric results were taken as a standard for comparison in the second table. It will be seen on examination that the results obtained with the Short test agree fairly well with those obtained by the gravimetric method; the greatest variation being .23 per cent. The results indicated by the lactoscope are variable throughout.

TABLE SHOWING PER CENT. OF BUTTER FAT BY THE LACTOSCOPE AND WITH THE SHORT TEST.

Lacto-scope.	Short.	Variation fr'm Short	Lacto-scope.	Short.	Variation fr'm Short	Lacto-scope.	Short.	Variation from Short.
3.50	3.70	—.2	3.65	3.70	.....	3.65	3.75	—.1
3.88	3.50	+.38	3.60	3.75	—.15	3.45	3.60	—.15
4.	3.85	+.15	3.50	3.90	—.4	3.50	3.80	—.3
3.35	3 95	—.6	3.43	3.75	—.32	3.60	4.	—.4
3.50	3.72	—.12	3.58	3.50	.....	3.50	3.50	.....
3.48	3.35	+.13	3.75	3.35	+.4	3.75	3.90	—.15
3.75	3.70	.....	3.95	3.68	+.27	4.20	3.75	+.55
3.85	3.68	+.17	3.80	3.75	....	3.75	3.98	—.23
3.90	4.25	—.35	4.20	3.75	+.45	3.85	3.75	+.1

TABLE SHOWING RESULTS OF TESTS OF FAT BY THE LACTOSCOPE, SHORT'S METHOD, AND THE GRAVIMETRIC METHOD.

Sample No.	Specific gravity.	Per cent. of fat, Lactoscope.	Per cent. of fat, Short's method.	Per cent. of fat, gravimetric method.
1	1.031	3.75	3.48	3.31
2	1.0315	3.25	3.95	3.78
3	1.032	3	3.60	3.37
4	1.0318	3.30	3.72	3.67
5	1.030	3.75	3.65	3.74
6	1.0315	3.65	3.84	3.72
7	1.031	3.50	3.47	3.47
8	1.0315	3.75	4.02	3.91
9	1.0317	3.90	3.83	3.71
10	1.0305	3.85	3.80	3.68
11	1.031	3.90	3.50	3.72
12	1.031	3.68	4.18	4.12
13	1.0308	4.15	4	3.98
14	1.032	3.50	3.82	3.90
15	1.031	3.88	3.75	3.65
16	1.032	3.60	3.80	3.65
	Averages.	3.65	3.78	3.71
	Extreme variations	+.44 −.53	+ 23 −.22	

Neither the lactoscope nor the Short test could be used in testing skim milk and buttermilk, as the readings of the former are two high; while the Short test gives but a trace of fat in skim milk, and only a fraction of the fat present in buttermilk.

ACTUAL YIELD OF THE CHURN COMPARED WITH RESULTS INDICATED BY THE SHORT TEST.

Through the kindness of Messrs. Gurler Bros., of DeKalb, Ill., the Station was afforded the opportunity of conducting these experiments at their creameries. The plan of work adopted was in accordance with that which would be pursued were the Short test used as a means of buying milk by its actual fat value. The tests were conducted for a period of twenty-two days; but four days' tests were not taken into consideration, because errors had crept in to destroy the results of the churn. (Portions of the cream or of the butter had been reserved and the butter weighed with the yield of the following day). At DeKalb and Shabbona the milk was poured into the receiving cans until they were about one-half to two-thirds full, when it was thoroughly mixed, sampled, and weighed. Individual samples were taken occasionally with the idea of testing the milk from each patron in this manner at least once a week. Two tests were made of each sample without using more than from thirty to forty testing flasks. At Malta, Ill., each patron's milk was sampled and weighed, and but one test made of each sample. This gave a daily individual record but involved the use of from sixty to seventy flasks, while the results were not so satisfactory because the test was not made in duplicate.

In order to find the amount of butter fat indicated by the test, the weight of each lot was multiplied by the per cent. of fat it contained as

shown in testing the sample taken from it. The sum of the results thus obtained is the weight of the butter fat in the milk received that day.

Below will be found tables, the first of which is a copy of the daily record kept at DeKalb, Malta, and Shabbona, respectively. Following this is a table showing the weight of butter fat indicated daily by the Short test, compared with the actual weight of salted butter obtained in churning the cream taken from the milk of the corresponding day.

TABLE SHOWING PER CENT. OF BUTTER FAT FOUND IN 88 LOTS OF MIXED MILK.

No. of patr'ns	Pounds of milk.	Average per cent.	Lb. of butter fat.	No. of patr'ns	Pounds of milk.	Average per cent.	Lb. of butter fat.
	DeKalb, June 17, 1889.						
3	694	3.35	23.249	3	764	3.90	29.796
5	729	3.83	27.92c	4	804	3.95	31.758
4	762	3.72	28.346	3	777	3.80	29.526
3	815	3.95	32.192	6	819	3.89	31.859
3	781	3.90	30.459	5	723	3.86	27.908
4	829	3.80	31.502	7	745	3.75	27.937
5	833	3.90	32.487	6	*742	4.12	15.120
2	778	3.92	30.498				
				63	11,220	3.83	430,557
	Malta, June 24, 1889.						
	510	3.55	18.105		63	3.46	2.180
	487	3.50	17.045		272	3.40	9.248
	369	3.90	14.391		30	3.75	1.125
	214	3.83	8.196		302	4	12.080
	176	3.07	5.403		81	4.20	3.402
	214	3.25	9.955		113	3.85	4.350
	245	3.85	9.432		62	3.75	2.325
	254	4	10.160		234	3.75	8.875
	332	3.25	10.790		139	3.75	5.212
	446	3.75	16.725		203	3.85	7.815
	422	3.55	14.981		96	3.30	3.168
	54	3.52	1.900		205	3.70	7.585
	307	3.45	10.591		257	3.90	10.023
	341	3.40	11.594		58	3.85	2.233
	17	3.77	0.641		337	3 82	12.873
	340	3.90	13.260		184	3.60	6.624
	20	3.76	0.752		147	3.75	5.512
	70	4.75	3.325		252	3.60	9.072
	210	3.50	7.350		5	3.77	0.188
	24	3.52	0.845		278	3.75	10.425
	393	3.75	14.737		205	3.75	7.687
	82	4.40	3,608		210	3.87	8.127
	150	3.90	5.850		195	3.35	6.532
	172	4.10	7.052		284	3.95	11.218
	47	3.50	1.645		245	3.50	8.575
	71	3.45	2.449		68	3.87	2.631
	278	3.80	10.564		92	3.75	3.450
	212	3.75	7.950		200	2.80	5.600
	112	3.60	4.032		180	3.85	6.930
	282	4.15	11.703				
	56	4.08	2.284	60	11,904	3.70	439,380
	Shabbona, July 3, 1889.						
6	869	3.92	34.064	4	1,093	3.35	36.615
6	1,072	3.76	40.305	4	1,060	3.55	37.630
7	1,098	3.45	37.881	4	1,043	3.75	39.112
3	1,047	3.68	38.529	7	1,031	3.75	38.662
7	983	3.80	37.354	7	1,566	3.61	56.532
6	1,031	3.74	38.559				
				61	11,893	3.66	435.243
	Grand totals and average per cent			184	35,017	3.73	1.305.180

At Malta the milk furnished by each patron was tested separately.

At Malta the milk furnished by each patron was tested separately.

*375 pounds taken for cheese.

TABLE SHOWING COMPARISON OF SHORT'S TEST WITH YIELD FROM THE CHURN.

Date.	Lb. of butter fat by Short's test.	Lb. of salted butter from churn.	Per ct. yield above or below the test.
DeKalb, June 14	429.385	455	+5.96
" " 15	423.185	442	+4.45
" " 17	430.557	415	−3.61
" " 18	428.783	438	+2.15
" " 19	431.354	437	+1.31
" " 20	425.795	432	+1.46
" " 21	431.885	438	+1.42
" " 22	429.03	443	+3.26
Malta, " 24	439.38	460.5	+4.81
" " 25	442.52	452	+2.14
" " 26	444.43	454.25	+2.21
" " 27	442.30	449	+1.51
" " 28	442.30	433	−2.10
Shabbona, July 1	437.872	421	−3.85
" " 2	413.527	414	+0.11
" " 3	*418.067	425	+1.66
" " 6	424.692	429	+1.01
		Average,	+1.41

* This is less than amount for same day in foregoing table, since some milk was used for cheese.

The yield in churning is influenced by many varying conditions, such as the temperature, the concentration of the cream, the degree of acidity, and the kind of fermentation which takes place in the cream. However, the Short test is trustworthy and gives results agreeing quite well with the actual churn yield. It could well be used as a standard test in paying for milk by its actual butter value, as the yield in excess of what had been indicated by the test could be distributed proportionately from time to time. Its adoption would offer an inducement for improving the quality of milk brought to the creamery, whereas at present the farmer can have no special object in trying to raise the standard, knowing that he will receive no more for good milk than for that of an inferior quality.

CHURNING TESTS.

At the time of making the tests comparing the results of the Short test with the actual yield of butter in the churn, it seemed desirable to interfere as little as possible with the work of the butter maker, in order that the results of the churn might truly represent those of daily practice. The work of churning the cream and working the butter was conducted by experienced hands. The cream was churned at a temperature beginning at 58° F., with the churn making about 45 revolutions a minute. The butter received two workings, the first immediately after its removal from the churn, at which time it was salted, the second after it had stood in the refrigerator over night, when it was then reworked, packed, and weighed.

For the purpose of locating the cause of the variation in the yield of the churn, the cream was examined each day during the latter part of the trial, and it was found that while the conditions of temperature and con-

centration were practically constant, the amount of acid that had developed during the ripening process varied considerably.

By comparing the results in the following table, it will be seen that the churnings which fell below the amount of butter fat indicated by the test, were made with cream in which the per cent. of acidity was comparatively low.

TABLE SHOWING CORRESPONDENCE BETWEEN ACIDITY AND YIELD OF BUTTER.

Date.	Per cent. acid.	Butter fat indicated by test. Lb.	Butter yield. Lb.
June 27.....	0.72	442.30	449
" 28.....	0 36	442.30	433
July 1.....	0.46	437.87	421
" 2.....	0.603	413.527	414
" 3.....	0.639	418.067	425
" 6.....	0.517	424.692	429

Further tests were therefore undertaken at the Station, the results of which will be found in an accompaning table, in order to see how the degree of acidity affected the yield of butter.

The term "per cent. of acidity," is used here merely for convenience, and is not to be interpreted as the exact measure of the acid present, but rather as *the lactic acid equivalent of the amount of alkali it took to bring about a neutral reaction in 50 c.c. of cream.*

In each trial the cream was thoroughly mixed, divided into two equal parts by weight, and allowed to ripen slowly under like conditions of temperature, a sample having been reserved for analysis. Tests of the acidity of the cream were made just before the churning, which was conducted in a small barrel churn at a temperature beginning at 58° F. The butter was worked in the churn and weighed before salting. Both butter and buttermilk were analyzed.

The second half of the cream, designated in the table as *b*. was allowed to stand until it had become strongly acid, when it was churned under the same conditions that had been observed in churning the first portion, *a*.

It will be seen on examination of the table that for the temperature employed in these trials, there was a large difference in butter yield in all cases where the first half of the cream had been churned before it had attained an acidity of .5 per cent.

TABLE SHOWING INCREASE OF ACIDITY AND YIELD OF BUTTER.

No. of trial.	Per cent. of acidity in *a*.	Per cent. of acidity in *b*.	Increase of yield, *b* more than *a*., per ct.
6	.466	.835	18.28
15	.460	.680	11.39
20	.450	.570	10,53

As the per cent. of acidity increases in the first half of the cream, the difference in the butter yield of *a* and *b* gradually decreases.

When *a* has attained .65 per cent. of acid, but a slight increase is obtained by further ripening of the cream; while at .7 per cent. the difference disappears.

It was found that the lactic fermentation proceeded rapidly until the cream had attained about .82 per cent. of acid, and that when this state was reached other fermentations seemed to take place so that the cream could not be kept without danger of spoiling.

TABLE SHOWING YIELDS OF BUTTER FROM CREAM OF DIFFERENT DEGREES OF ACIDITY.

Date.	No. of trial.		Ounces, cream.	Per cent. acidity.	Ounces, butter.	Per cent. increase.	Analysis.		Per cent. fat, buttermilk.	Per cent. fat, cream.	Temperature beginning, F.	Temperature ending, F.	Time of churning, minutes.
							Water.	Fat, etc.					
July 17	2	*a*	176	.50	38	.....	14.42	85.58	.....	.....	58°	68°	52
" 18		*b*	176	.808	42.2	11.05	15.96	84.04	.....	.....	58°	66°	21
" 19	3	*a*	160	.585	37.5	.....	14.90	85.10	.....	.....	58°	.....	30
" 20		*b*	160	.810	40.5	8	14.29	85.71	.....	.....	58°	63°	25
" 23	4	*a*	290.5	.789	72.5	0.34	15.53	84.47	.....	.....	55°	64°	56
" 25		*b*	290.5	.834	72.25	.....	14.81	85.19	.....	.....	55°	64°	55
" 24	5	*a*	203	.567	43.75	.....	14.02	85.98	.....	.....	58°	.....	32
" 25		*b*	203	.781	47.25	8	13.94	86.06	.....	.....	58°	65°	30
" 27	6	*a*	232	.466	46.5	.....	14.50	85.50	.....	.....	58°	.....	43
" 29		*b*	232	.835	55	18.28	15.60	84.40	.....	.....	58°	69°	41
" 27	7	*a*	122.5	.504	24.5	.....	14.70	85.30	.....	.....	58°	67.5°	33
" 29		*b*	122.5	.81	27.75	13.26	13.09	86.91	.....	.....	58°	.....	26
" 29	8	*a*	99	.661	23	.....	16.86	83.14	2.015	21.075	58°	65°	16
" 30		*b*	99	.786	23.25	1.09	14.67	85.33	1.44	21 075	58°	64°	14
" 31	9	*a*	101	.615	23.5	.....	15.61	84.39	1.55	22.01	58°	65°	20
Aug. 2		*b*	101	.778	24	2.12	14.21	85.79	.835	22.01	58°	63°	14
" 3	12	*a*	112	.677	27.5	.....	16.81	83.19	1.015	.....	58°	65°	26
" 5		*b*	112	.783	28.25	2.73	15.32	84.68	.....	.....	58°	64°	20
" 5	13	*a*	132	.505	25.5	.....	14.89	85.11	2.955	19.67	58°	64°	27
" 6		*b*	132	.789	27.25	8.82	13.15	86.85	1.560	19.67	58°	64°	27
" 9	14	*a*	108	.569	23	.....	14.01	85.99	2.48	20.85	58°	63.5°	25
" 10		*b*	108	.700	25	8.69	13 37	86.63	1.35	20.85	58°	64°	23
" 9	15	*a*	117	.46	19 75	.....	14.80	85.20	2.80	.....	58°	.....	15
" 10		*b*	117.	.68	22	11.39	14.16	85.84	.782	.....	58°	63°	17
" 10	16	*a*	118	.560	21.5	.....	15.37	84.63	1.96	16.40	58°	64.5°	20
" 12		*b*	118	.753	22	2.33	13.45	86.55	.951	16.40	58°	.....	21
" 12	17	*a*	116	.520	19	.....	13.94	86.06	2.31	16.59	58°	.....	20
" 13		*b*	116	.670	19.25	1.32	13.57	86.43	1.73	16.59	58°	.....	19
" 12	18	*a*	108	.527	18	.....	14.66	85.34	2.19	17.94	58°	63°	15
" 13		*b*	108	.753	20	11.11	14.37	85.63	1.10	17.94	58°	65°	18
" 14	20	*a*	116.5	.450	19	.....	12.79	87.21	.....	.....	58°	63°	22
" 15		*b*	116.5	.670	21	10.53	13.54	86.46	1.25	.....	58°	65°	18
" 24	26	*a*	137.5	.698	26.5	.....	16.74	83.36	2.23	.....	58°	65°	17
" 27		*b*	137.5	.785	26	1.92	17.12	82.88	3.804	.....	58°	64°	17
" 1	10	*a*	106	.570	24.5	.....	14.78	85.22	1.21	21.40	58°	.....	19
" 3		*b*	106	.820	26	6.12	19.96	80.04	1.31	21.40	58°	65°	15
" 2	11	*a*	122	.499	25.5	.....	15.89	84.11	2.235	20.99	58°	63°	23
" 3		*b*	122	.782	29.5	15.69	21.91	78.09	1.23	20.99	58°	63°	21
" 14	19	*a*	117.5	.81	20	.....	.....	.....	.....	15.18	58°	64°	....
" 14		*b*	117.5	2.384	20.25	1.25	.....	.....	.....	15.18	58°	.....	26
" 6	27	*a*	130	.680	28.5	.....	.....	.....	.....	.....	58°	65°	....
" 6		*b*	130	1.080	29	1.75	.....	.....	.....	.....	58°	64°	....
" 6	28	*a*	115	.775	26.5	1.92	.....	.....	.....	.....	58°	64°	...
" 6		*b*	115	1.175	26	.....	.....	.....	.....	.....	58°	66°	...

In the churning made at DeKalb, the cream was divided into two portions. One-half was churned sweet at a temperature of 55° F., while the second half was allowed to ripen, when it was churned at 60° F. The yield of the sweet cream churning was but little below that of the ripened cream, as seen below.

In order to try the effect of larger quantities of acid on the yield of butter, in trials 19, 27, and 28, the cream was allowed to ripen, when one-half, *a*, was churned as usual, but the second half, *b*, was acidified with acetic acid previous to churning. In two cases there was a slight increase over the yield of *a;* in the third, *b* gave a smaller yield than *a*. It would seem, therefore, that a higher degree of acidity than .7 to .8 per cent. would not materially affect the yield of butter, while it would be highly dangerous to the quality to allow the cream to stand after it had reached that point.

On the other hand, in using the churning temperature of 58° F. (60° F. in winter), a regular increase in the yield is observed as the cream ripens, until the latter has acquired about .7 per cent. of acid.

The analyses of the buttermilk and of the butter from each churning showed that there was more fat left in the buttermilk from *a* than in that from *b*, and that the quality of the butter in churning the cream sour was superior to that obtained from the corresponding portion that had been churned with a smaller per cent. of acid. Exceptions to this statement were found in trials 10, 11, 2, 20, and 26. In the two trials 10 and 11, the cause of this variation was explained by the fact that the cream *b* in each case had spoiled. A different fermentation had set in after the cream had ripened, which was highly detrimental to the quality of the butter. In trials 2, 20, and 26, the difference in the quality of the butter was not so marked as in the two foregoing cases, but it was probably caused by the same detrimental fermentations. [See table on page 300.]

*Churning Sweet Cream.

In connection with churning sweet cream, a method has been proposed by Prof. John A. Myers, of the West Virginia Station, in which the fat in the buttermilk is recovered by means of the centrifugal machine. At the request of Professor Morrow, a few tests were conducted in order to find how much fat could be recovered in this manner.

Sweet cream churned at the same temperature as sour, would give a poor yield of butter, leaving a large per cent. of fat in the buttermilk. It has been found that the best churning temperature for sweet cream is from 51° to 55° F., when all but a few per cent. of the butter fat can be recovered.

[*This sweet cream butter was sold at a considerable loss, the dealers objecting to it. It has been suggested that the coloring matter used may have had some effect, the flavor of the butter being much more mild than that of butter made from acid cream. It may have been, however, that the claim of inferior quality rested only on the fact that the flavor of the butter did not suit tastes educated to prefer a sharper and more distinct flavor.—G. E. Morrow.]

TABLE COMPARING YIELDS FROM SWEET AND SOUR CREAM.

No.	Lb. butter per 100 lb. milk sour cream.	Per cent. fat in butter-milk.	Lb. butter per 100 lb. milk sweet cream.	Per cent. fat in butter-milk.	Per cent. loss in churn, sweet cream.
1	.....	.....	4.05	1.17	.....
2	4.38	.41	4.19	.72	4.35
3	4.35	.51	4.22	.69	2.99

The sweet cream buttermilk was run through the separator, but no fat could be recovered in this manner.

"ALBERT G. MANNS, *Chemist.*"

THE COMPARATIVE VALUE OF CORN-FODDER AND ENSILAGE IN FEEDING YEARLING HEIFERS.

Experiment No. 99.

This experiment was conducted with a view of determining, so far as one experiment may, the comparative value of corn (stalk and ear),when field-cured for corn-fodder and when made into ensilage, in the production of live increase in cattle. For this purpose four yearling heifers were fed all they would eat of corn-fodder and four others of a similar character were fed ensilage, the grain and hay eaten by both lots being alike. During the weeks following, both lots were fed corn-fodder.

It was found that the gain in weight of both lots was practically identical for the whole period, although slightly in favor of the heifers fed field-cured corn-fodder.

The heifers fed ensilage ate more and required more water-free substance to make a pound of increase than those fed corn-fodder. The former, however, ate a larger percentage of the food given them, so that a part of the extra amount which they ate was wasted.

Three theories may be advanced to account for the fact that the heifers fed ensilage required more pounds of water-free food to make a pound of increase.

1. The analyses made by Mr. Farrington (these are to be found on pp. 316 to 320) show that the character of the protein in the corn-fodder had been considerably changed by ensilaging. Protein is divided into two forms, albuminoid and non-albuminoid. It is generally held that the former only, of all the food elements, can produce muscle. The analyses, therefore, show that the muscle-forming nutrients had been reduced 33 per cent. in the ensilage.

2. About seven pounds more water was consumed daily by each heifer fed ensilage than by those fed corn-fodder. There is every presumption that the heifers fed corn-fodder had all the water that they required for

healthy growth. It has been shown *experimentally that an excessive use of water is harmful. As the heifers fed ensilage gained no more than the others, seven pounds of water or other substance had to be eliminated daily from the system. This required extra work of the excretory organs. This work used up food.

It is not at all improbable that more water would be evaporated from the skin. About sixteen times as much heat is rendered latent when water is evaporated at the temperature of the body, as is required to raise the same quantity from freezing to the temperature of the body.[1] This heat requires fuel (food) to produce it. The evaporation of water from the skin is one of nature's methods of maintaining a uniform temperature of the body. Much less water is required in cold than in warm weather.

3. It has been suggested by a German investigator, H. Weiske, that inasmuch as the ensilage relaxes the bowels, all the food given passes through the animal more quickly, and hence less is digested[2].

The relative digestibility of field-cured and ensilaged fodders, however, is still unsettled. [3]Sturtevant and [4]Woll found ensilage more digestiable than fodder. [5]Weiske found esparcet more digestible than the same ensilaged. Recently [6]Armsby has reported a carefully conducted experiment in which he found corn-fodder more digestible than ensilage.

Details of the experiment follow.

The Animals Used.

Eight yearling heifers were used in this test. All were out of thoroughbred Shorthorn cows, and all but one, No. 8, were sired by the Shorthorn bull, Royal Butterfly 83,410. The following table gives the name, date of birth, dam, and sire of each.

TABLE Showing Character of Animals.

No.	Name of animal.	Date of birth.	Dam.	Sire.
1	Duchess of York.....	Sept. 17, 1888...	Duchess of York 21st	Royal Butterfly 83410
2	Bloomanthe.....	Sept. 19, " ...	Bloomanthe 4th....	"
3	Queen Mary.....	Oct. 14, " ...	Queen Mary 8th....	"
4	Queen Mary	Nov. 1, " ...	Queen Mary 11th...	"
5	Sharon Pearlette.....	Oct. 1, " ...	Sharon Pearlette 2d.	"
6	Grace	Dec. 22, " ...	Grace 3d	"
7	Grace	Sept. 10, " ...	Grace 6th.....	"
8	Grace	June 20, " ...	Queen Mary 15th...	A grade Shorthorn.

* Armsby's Manual of Cattle Feeding, 3d Edition, p. 135.

1. Ganot's Physics, tenth addition, p. 309.

2. Jour. fur Landw., 33, § 82.

	Digestible substance.			
	Organic.	Protein.	Fibre.	Nitrogen-free extract.
"Green esparcet.....	66.35	72.50	42.16	78.29
Ensilage esparcet.....	44.93	50.25	28.77	53.20
Difference.....	21.42	22.25	13.39	25.09

A reason for this bad use of ensilage may lie in this; that this fodder, on account of its sour condition, accelerates the peristaltic movements of the intestines and thus causes a quicker passage of the fodder through the digestive apparatus, so that a sufficient solution and resorption of the nutrients cannot take place.

3 Third Report, New York Experiment Station, 1884. pp. 26–49.

4 Fifth Report, Wisconsin Experiment Station, 1888, pp. 56–61; 6th Report, 1889, pp. 69–122.

5 Jour. fur Landw. 25, 170.

6 Penn. Experiment Station, bulletin No. 9, October, 1889.

They were divided into two lots with reference to their weight and supposed feeding quality, as judged by appearance and past experience in feeding them. Heifers 1 to 4 were fed corn-fodder, and heifers 5 to 8 were fed ensilage. They were a thrifty and fairly even bunch, well adapted to the work in hand, except possibly in age and consequent lack of size.

Food Given and Eaten.

During two weeks, December 23, 1889, to January 6, 1890, while the heifers were getting accustomed to their quarters, they were each fed daily six pounds of middlings and one feed of both corn fodder and and ensilage.

The time covered by the feeding test was 84 days, January 6 to March 31, 1890, and may be divided into three periods as follows:

Period 1, January 6th to January 30th.....24 days.
Period 2, January 30th to March 10th.....39 days.
Period 3, March 10th to March 31st .....21 days.

The duration of the first two periods was controlled by the supply of ensilage.

During the three periods each heifer had six pounds of crushed oats daily, and each pair (heifers 1 and 2, 3 and 4, etc.), had four pounds of clover hay daily. With the exception of the first day or two, all given of both oats and hay was eaten.

During period 1, heifers 1 to 4, were fed corn fodder from Burrell and Whitman ensilage corn, and heifers 5 to 8 were fed ensilage from the same. During period 2, heifers 1 to 4 were fed corn-fodder from Burr's white corn, and heifers 5 to 8 were fed ensilage from the same; and during period 3, all were fed corn-fodder from Burr's white corn.

Growing and Harvesting the Corn. The four acres used for growing the corn had been in meadow for several years, and in the spring 75 loads of stable manure were put on it. May 18, 1889, it was planted with an ordinary two-horse corn-planter drill in rows 3 ft. 8 in. apart. The stubs on an acre of each variety were counted after the corn was removed. In the Burr's white there was one stalk every 13 inches, and in the Burrell and Whitman, the stalks were about one inch further apart.

Both acres of Burr's white were cut September 24th to 26th, and both acres of Burrell and Whitman ensilage corn, September 25th to 28th. One acre of each variety was cut up (about inch lengths) and put into a silo, and one acre of each was shocked and left standing in the field until wanted. The respective acres from which the corn-fodder and ensilage were made lay side by side and were 2 x 80 rods.

At the time of cutting, the ears of Burr's white were mostly glazed, the lower leaves were beginning to get dry, and occasionally the husks were dry. The ears of Burrell and Whitman corn were largely in the milk and the leaves and husks were green. At this time one hundred pounds of stalks of each variety was taken as cut, and the following items ascertained. The stalks were cut about 15 in. high.

	Burr's white	Burrell and Whitman ensilage corn.
Height of stalks	7 ft. 9 in.	8 ft. 8 in.
Number of nodes	11	13
Number of stalks	47	34
Number of ears	42	29
Pounds of ears	32.5	19.5
Pounds of bare stalks	32.5	36.5
Pounds of leaves and husks	34.5	43

The corn-fodder was hauled from the field twice a week, and run through the feed cutter in the same manner as the green corn which had previously been put into the silo. Each time the required quantity was cut it was put into a compartment of a comparatively tight box, and another compartment was filled with ensilage from the silo. This quantity served three or four days. This method was necessitated by the burning of the experiment barn and silo in September, 1889. Little difficulty was experienced in keeping either the ensilage or corn-fodder in this way. No selection of shocks or fodder was made. The shocks were taken one after another, each in its turn, and all of every shock was used. As in feeding only four heifers, the ensilage would not be removed fast enough to keep the exposed surfaces fresh, ensilage was fed regularly to other stock. Any that was rotten or otherwise spoiled was rejected. The waste in the silo this season, from this cause, may be roughly estimated at 10 per cent.

Method of Feeding.

The daily routine was about as follows:

6:30 a. m., removed and weighed corn-fodder and ensilage left uneaten from previous evening feed.

7 a. m., fed crushed oats.

7:30 to 8 a. m., fed corn-fodder and ensilage.

9 to 10 a. m., weighed animals, removed and weighed corn-fodder and ensilage not eaten, and watered in stall.

10 a. m., to 3:30 p. m., heifers ran in a small lot, during which time clover hay was placed in mangers.

3:30 to 4 p. m., stabled and watered.

4 to 4:30 p. m., fed crushed oats.

5 to 6 p. m., fed corn-fodder and ensilage.

Period 1. During period one, January 6–30, 1890, heifers 1 to 4 were each given 12 pounds daily (5 lb. in the morning and 7 lb. in the evening) of Burrell and Whitman corn-fodder, and heifers 5 to 8 were each given from January 6th to January 15th, 25 pounds (10 in the morning and 15 in the evening), of Burrell and Whitman corn ensilage; from January 15th to 27th, 28 pounds (12 in the morning and 16 in the evening); and from January 27th to 30th, 30 pounds (13 in the morning and 17 in the evening).

The constant aim was to give each animal the same quantity of crushed oats, and each pair the same quantity of clover hay, and to allow each animal all the corn-fodder or ensilage it would eat, though recognizing that with full feeding some of the coarser parts of each would not be eaten.

The following table gives the number of pounds of corn-fodder and ensilage eaten by each animal each day during period 1.

TABLE SHOWING POUNDS OF CORN-FODDER AND ENSILAGE EATEN.

Date.	Corn-fodder.				Ensilage.			
	1	2	3	4	5	6	7	8
Jan. 6.....	*3.75	*5.25	*4.5	*4.00	*13.25	*10.75	* 8.75	*10.75
" 7.....	6.25	9.75	6.25	5.50	23.25	20.50	16.75	20.50
" 8.....	7.75	10.25	7.75	6.25	24.50	22.00	22.00	22.75
" 9.....	6.75	10.00	6.25	6.75	25.00	23.50	24.75	21.75
" 10.....	6.50	9.75	8.00	6.25	23.00	21.75	23.00	21.00
" 11.....	7.00	10.50	7.50	7.75	24.00	20.25	25.00	17.25
" 12.....	8.50	10.75	7.75	7.50	21.75	20.25	24.00	17.75
" 13.....	6.50	8.00	8.00	7.50	24.50	22.00	24 75	22.00
" 14.....	6.25	7.00	6.50	4.00	25.00	21.00	25.00	22.75
" 15.....	6.50	8.00	7.75	6.00	26.00	22.50	26.00	21.50
" 16.....	5.75	8.25	7.75	5.50	27.25	22.75	27.00	21.75
" 17.. ...	6.00	9.00	8.00	5.00	26 50	22.00	28.00	21.00
" 18.....	6.00	8.25	8.00	5.25	27.50	23.75	26.50	21.75
" 19.....	7.25	8.00	7.50	5.75	27.00	22.00	26.00	18.25
" 20.....	7.75	8.75	7.25	6.25	28.00	28.00	25.50	20.00
" 21.....	6.25	9.50	7.75	5.75	27.50	26.75	28.00	23.00
" 22.....	6.25	9.25	7.75	6.25	27.75	25.25	28.00	21.25
" 23.....	5.75	10.25	8.75	6.50	28.00	26.00	27.75	20.50
" 24.....	6.75	9.25	8.75	5.75	26.50	25.00	28.00	23.25
" 25.. ...	6.50	8.75	9.00	4.00	23.50	27.50	27.75	22.75
" 26.....	8.50	10.25	8.75	4.75	25.00	24.50	27.25	16.75
" 27.....	7.25	9.25	9.00	7.00	28.25	27.50	28.75	20.75
" 28.....	7.75	8.75	7.25	7.50	29.50	29.50	30.00	21.00
" 29.....	7.75	8.25	9.00	5.50	30.00	26.00	28.75	16.00
" 30.....	†3.25	†4.50	†3.75	†2.50	†12.50	†11.25	†12.50	†10.25
T'l,24 d'ys	164.00	219.50	188.50	144.75	625.00	572.25	619.75	496.25

*Evening feed only. †Morning feed only.

Three samples of Burrell and Whitman corn-fodder and ensilage were taken (December 27th, January 2d, and January 3d) and the percentage of water determined in each. The corn-fodder contained an average of 40.4 per cent. and the ensilage, 75.1 per cent. of water. The high percentage of water in the corn-fodder was due to the excessive rains which continued through this period, the rainfall for January, 1890, being 5.26 in., while the normal for central Illinois during ten years is only 1.54 in., for January.

The following table gives the quantity of fresh and water-free substance given and eaten in the corn-fodder and ensilage per day per animal, and the per cent. eaten. In this case, in estimating the water-free substance eaten, it is assumed that the quantity eaten contains the same percentage of water as that given. This involves an error, for Mr. Farrington's analyses, made during period 2, show that the portion eaten contains a less percentage and that not eaten a larger percentage of water than the total quantity given.

Period 1. January 6th to 30th, 24 days, the corn-fodder and ensilage fed per day per animal, was:

	Corn-fodder.		Ensilage.	
	Fresh.	Water-free.	Fresh.	Water-free.
Pounds given.....	12	7.15	27.1	6.75
Pounds eaten.....	7.46	4.45	24.25	6.04
Per cent. eaten.....	62.2	62.2	89.5	89.5

The total quantity of food eaten per day per animal, during period 1 was:

	Heifers fed corn-fodder.		Heifers fed ensilage.	
	Fresh.	Water-free.	Fresh.	Water-free.
	lb.	lb.	lb.	lb.
Corn-fodder or ensilage	7.46	4.45	24.25	6.04
Crushed oats	6	5.19	6	5.19
Clover hay	2	1.64	2	1.64
Total per animal	15.46	11.28	32.25	12.87
Total per 1,000 lb. live wt.		15.91		17.70

Period 2. During period 2, January 30th to March 10th, heifers 1 to 4 were each given 12 pounds daily (5 lb. in the morning and 7 lb. in the evening) of Burr's white corn-fodder, and heifers 5 to 8 were each given 30 pounds (13 in the morning and 17 in the evening) of Burr's white ensilage.

The following table gives the number of pounds of corn-fodder and ensilage eated by each animal each day during period 2.

TABLE SHOWING POUNDS OF CORN-FODDER AND ENSILAGE EATEN.

Date.	Corn-fodder.				Ensilage.			
	1	2	3	4	5	6	7	8
Jan. 30	*4.75	*5.5	*5.75	*2.75	*16.75	*16.75	*16.00	*12.75
" 31	8.5	9.75	10	6.75	27.75	23.75	30	20.25
Feb. 1	9.25	10	9.25	6.25	28.25	26.5	30	21.75
" 2	8.75	7	9.25	8.75	27.75	20.75	29.75	22.25
" 3	9	8.75	9.5	6.25	28	24.75	30	20.75
" 4	9	9.75	10.25	3.75	21.5	17.5	27.75	17.25
" 5	9.5	9.5	10.25	6	23.75	20	28	7.75
" 6	9.5	10.25	10.25	6.25	29	27.75	29.75	23
" 7	9.5	9	10	5.75	28	23.5	30	23
" 8	8	10.5	10.25	7.75	25.5	27.5	30	22.5
" 9	10.25	9.25	10.25	7	20.25	24.25	30	22.2
" 10	8.75	9.75	9.75	7	19.25	20.75	28.5	17.75
" 11	8.5	9.5	10	6.75	20.75	18.75	29.75	21
" 12	10	9.5	9.75	7	23.5	24	30	24
" 13	9.5	10.5	10	8.5	27.5	25	30	25.5
" 14	9.25	10.75	10.25	7.5	25.25	14	29.75	25.25
" 15	9.25	9.75	10	7.5	23.25	16.25	29.5	22.5
" 16	8.75	9.5	9.25	7.5	20.00	15	28.25	21.5
" 17	9.75	10.25	10.25	8.	23.5	19	30	23.5
" 18	9.75	10.25	10.25	7.75	26	16.5	30	26.5
" 19	9.5	10.25	9.75	7.75	27.5	17.25	30	27.25
" 20	9.5	9.5	9.5	7.25	27.5	22.25	30	25.75
" 21	8.25	7.75	9.5	7.25	29	24.25	30	23.75
" 22	9	9.25	9.5	6.75	28.5	22.75	30	22.5
" 23	8.5	9.5	9.5	7.25	28	20.75	28.5	22.25
" 24	8.5	9.25	9	7	26.75	26.25	30	23.5
" 25	8.25	7.75	10	8	28	22.75	30	24.75
" 26	8	8.75	9.5	8	27	22.75	30	21
" 27	8.75	10.5	10	7.75	27.75	24.75	30	18
" 28	8.25	10.5	8.75	7.75	22.25	28.5	30	22.25
Mar. 1	7.75	10	9.75	7.5	26.75	28	30	23.75
" 2	9.25	9.25	10	7	27.5	26	30	23.75
" 3	10	10	9.5	5.75	27.5	25.25	29.75	22
" 4	9.25	10.25	9.75	7.75	26.75	13	30	18.75
" 5	8.25	9	9	6.50	21.25	21.75	30	20.75
" 6	7.75	9.25	9	6.75	20.75	26.75	29.5	16
" 7	9.25	8.5	8.5	5	22.5	26.50	29.5	19.75
" 8	7.75	7.75	8.75	5.75	20.25	24.5	29.75	13
" 9	9	10	9.25	6	17.75	24	29	14.25
" 10	†3.5	†4	†4	†2.5	†8	†12	†13	†9.75
Total 39 days	347.75	370.00	377.00	270.00	976.75	882.25	1156.00	833.75

*Evening feed only. †Morning feed only.

In the analyses of duplicate samples of corn-fodder and ensilage taken weekly during this period (pp. 316 to 320), Mr. Farrington finds that the corn-fodder contained 32.19 per cent. of water, of which that not eaten and weighed back, contained 51.65 per cent. of water; and that the ensilage given contained 72.30 per cent. of water, of which that not eaten contained 78.32 per cent of water. It has heretofore been determined by this Station that the stalks of growing corn, when the ears have become glazed, contain a much larger percentage of water than either the ears or the leaves and husks.* It would seem from these analyses that the relative percentage of water in the stalks of the cured corn-fodder is greater than the stalks of the ensilage.

The percentage of waste in feeding both corn-fodder and ensilage is less than is indicated by the percentage of fresh substance not eaten.

The following table will show this:

Period 2, January 30th to March 10th, 39 days. The composition of the corn-fodder and ensilage eaten and refused per day per animal was:

	Corn-fodder.		Ensilage.	
	Fresh.	Water-free.	Fresh.	Water-free.
Pounds given	12.	8.14	30.	8.31
Pounds not eaten	3.25	1.58	5.94	1.29
Pounds eaten (by difference)	8.75	6.56	24.06	7.02
Per cent. eaten of that given	72.9	80 6	80.2	85.6

In this case the amount of water-free substance was determined by first computing the water-free substance in the food given and in that not eaten, and then taking the difference. If, as in period 1, the water-free substance eaten had been computed by assuming that the fresh substance eaten contained the same percentage of water as the food given, the pounds of water-free corn-fodder eaten daily would be 5.93 instead of 6.56, and of water-free ensilage 6.66 pounds instead of 7.02 pounds.

The total pounds of food eaten per day per animal, during period 2 was:

	Heifers fed corn-fodder.		Heifers fed ensilage.	
	Fresh.	Water-free.	Fresh	Water-free.
Corn-fodder or ensilage	8.75	6.56	24.06	7.02
Crushed oats	6.	5.19	6.	5.19
Clover hay	2.	1.64	2.	1.64
Total per animal	16.75	13.39	32.06	13.85
Total per 1,000 lb. live wt.		17.44		17.51

Period 3. During period 3, March 10th to 31st, heifers 1 to 8 were each given 12 pounds of Burr's white corn-fodder daily. The following table gives the number of pounds of corn-fodder eaten by each animal each day during the period:

*Bulletin No. 4, p 91.

TABLE SHOWING POUNDS OF CORN-FODDER EATEN.

Date.	Corn-fodder.				Corn-fodder.			
	1	2	3	4	5	6	7	8
March 10	5.5	5.75	5	5.75	5.25	5.25	5	4.5
" 11	7.25	11	9.25	6	8.75	9.25	9.25	9.25
" 12	8.5	10.25	8.25	6.75	7.75	9.5	9	8.5
" 13	9.02	10.25	9.25	7.25	7.5	10	9	7.5
" 14	8.25	9.75	9.25	7.25	6.75	9.5	9.25	8
" 15	7	9.25	8.5	7	4.75	9	9.25	8.5
" 16	8.25	9	8.25	7	5.75	8.5	8.5	7
" 17	9	9.75	7.25	6	6	7.75	8.5	8.25
" 18	8.25	8.5	8.25	6.75	5	8 75	8.75	7
" 19	7.5	9	8.5	6.25	6.25	10	9	8
" 20	8	9.25	7.75	6.75	6.5	9.25	8.75	6.75
" 21	8.25	9.75	8.25	7.25	6.25	8.75	8.75	7.75
" 22	9	9.75	8.75	8.25	7.25	8.5	9.75	7.25
" 23	8	9.5	8.75	7.75	7.75	8.75	9.25	4.75
" 24	8.25	9.75	9.75	8	8.75	8.75	9.25	8
" 25	8	9.5	9	7.5	8.75	9.5	8.25	8
" 26	7 75	9	9.5	8.5	8.75	8.5	9.75	7.75
" 27	8.25	9.25	9.5	7.5	8.75	9.75	9.25	7.75
" 28	8.25	8.75	9.75	7	7.75	8.5	9	7.5
" 29	9.00	9.25	9.25	7.25	8.00	9.5	9.75	8.5
" 30	7.50	9.25	9	8	8.25	9	8.5	7.25
" 31	2.75	3.75	3.75	3	3.75	4	3.5	3.75
Total, 21 days	171.50	199.25	184.75	152.75	154.25	190.25	189.25	161.50

Taking 32.19 as the per cent. of water in the corn-fodder given, and 51.65 as the per cent. of water in that not eaten, we have the following:

Period 3, March 10th to 31st, 21 days. The pounds of corn-fodder per day per animal was:

	Corn-fodder.		Ensilage.	
	Fresh.	Water-free.	Fresh.	Water-free.
Pounds given	12.	8.14	12.	8.14
Pounds not eaten	3.57	1.73	3.73	1.80
Pounds eaten	8.43	6.41	8.27	6.34
Per cent. eaten of that given.	70.3	78.7	68.7	77.9

The total pounds of food eaten per day per animal during period 3, was:

	Heifers fed corn-fodder.		Heifers fed ensilage.	
	Fresh.	Water-free.	Fresh.	Water-free
Corn Fodder	8.3	6.41	8.27	6.34
Crushed oats	6.	5.19	6.	5.19
Clover hay	2.	1.64	2.	1.64
Total per animal	16.43	13.24	16.27	13.17
Total per 1,000 lb. live wt.		16.25		15.92

Summary. The total pounds of food eaten per day per animal, during the 12 weeks, January 6th to March 31st, may now be computed from the foregoing tables, and was:

	Heifers fed corn-fodder.		Heifers fed ensilage. (during periods 1 and 2).	
	Fresh.	Water-free.	Fresh.	Water-free.
Corn-fodder or ensilage	8.3	5.92	20.17	6.57
Crushed oats	6.	5.19	6.	5.19
Clover hay	2.	1.64	2.	1.64
Total per animal	16.3	12.75	28.17	13 40
Total per 1,000 lb. live wt.		16.87		17.55

Water Consumed.

During two weeks, February 17th to March 2d inclusive, the pounds of water consumed was ascertained, and is given in the following table:

TABLE Showing Pounds of Water given at Morning and Night Feb. 17th to March 2d.

Date.	No. 1.		No. 2.		No. 3.		No. 4.		No. 5.		No. 6.		No. 7.		No. 8.	
	M.	N.	M.	N.	M.	N.	M.	N.	M.	N.	M.	N.	M.	N.	M.	N.
17	26	25	21	24	36	18	25	17	26	18	16.5	10	18	20	0	18
18	21	20	20	12	30	24	26	12	36	14	13	0	29	16	0	26
19	0	22	25	20	20	19	25	18	22	12	14	1	17	0	0	48
20	17	0	19	12	26	10	15	16	24	1	5	20	26	6	0	7
21	24	13	40	15	11	19	14	26	26	16	20	15	18	18	0	31
22	22	6	19	13	24	34	14	17	21	18	3	0	19	21	0	0
23	26	20	24	25	25	19	26	11	7	14	7	13	17	23	26	26
24	25	19	25	19	19	19	20	20	23	19	10	9	27	18	0	51
25	8	17	32	19	37	22	20	20	20	19	19	0	23	16	0	4
26	18	20	0	22	24	16	20	13	17	13	15	13	24	12	27	0
27	0	19	16	21	26	18	24	17	18	16	13	14	21	17	26	0
28	0	26	20	22	25	18	6	15	5	7	0	17	18	18	0	21
1	19	19	21	21	19	32	24	20	25	18	7	21	26	24	26	26
2	26	25	26	26	19	19	21	16	16	13	13	5	19	18	25	0
Total.	232	251	308	278	341	287	280	238	286	198	155.5	147	302	227	130	258

All the water consumed daily per animal, during the two weeks was, in pounds:

	Heifers fed corn-fodder.	Heifers fed ensilage.
Water drunk	39.5	30.4
Water in corn-fodder or ensilage	2.2	18.6
Water in oats	0.8	0.8
Water in clover hay	0.4	0.4
Total water consumed daily	42.9	50.2

Weight of Animals.

Each animal was weighed daily between 9 and 10 a. m., throughout the entire time of the experiment. The weighing was done after the morning feeding and before watering. A pair of Fairbank's bullock scales were used, which weighed accurately to a pound.

The table on pp. 311 to 312 gives the daily weight of each animal for the three periods, and the diagram on the page following shows graphically the average daily weight for each lot of four heifers.

In this test the measure of value of the food given is taken to be the increase in weight of the animals receiving the food. This is not necessarily an entirely accurate measure of value, but is the only standard practicable with growing and fatting animals in a test of this nature. That important and complex element, quality, as affected by the food given, should never be overlooked; but where the quantity and composition of the food given was so similar, little or no variation in quality was to be expected, and indeed none has been detected.

It is not an easy matter, however, to get the true measure of increase in a given animal or lot of animals even when daily weights are taken;

much less when the weights are taken at longer intervals. In this experiment weights were taken daily, and every precaution was taken to have the animals weighed under similar conditions each day. They ate with reasonable regularity, made good gains, and were throughout the test in the best of health. Yet a glance at the table of individual weights, or at the diagram of average weights, will show striking daily variations.

An average increase of 25 lb. per animal in one day, and, again a decrease of 20 lb. may be noted. It should be mentioned that the marked variations in weight from March 6th to 9th, were caused, undoubtedly, by an enforced temporary change of water and method of watering. The grade Shorthorn heifer, No. 8, showed the most variation. The weights from March 25th to 30th, may be given in illustration; viz., 891, 854, 868, 869, 900, and 907 lb. See also weights from February 10th to 25th.

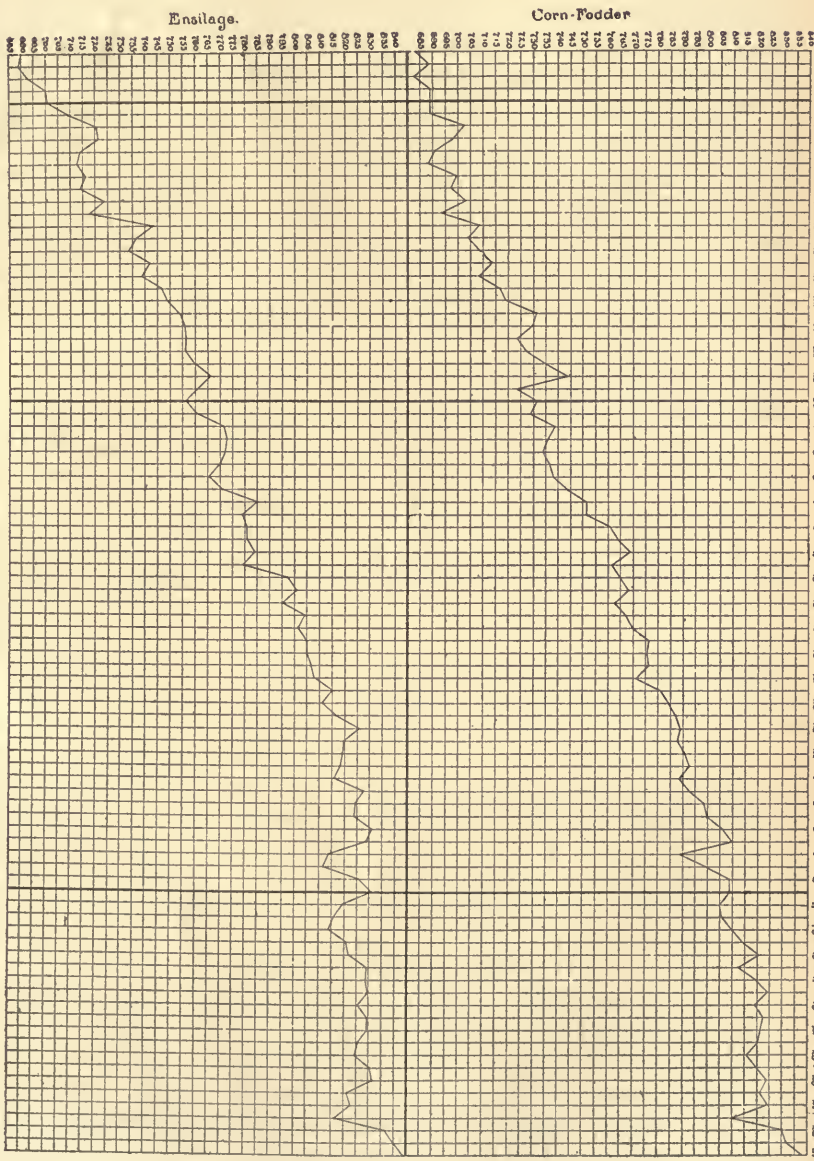
Although, in general, the average daily variations of each test were somewhat similar, it is apparent that a comparison of particular days might be misleading. It was decided, therefore, to take the average weight of five days preceeding the beginning or ending of any period, and these are given in the following table:

TABLE Showing daily Weights of Heifers.

Date.	1	2	3	4	5	6	7	8
	Period	*1. Anim*	*als fed*	*B. & W.*	*corn-fo*	*dder an*	*d ensila*	*ge.*
Jan. 2.....	629	749	660	696	712	613	703	732
" 3.....	637	760	670	685	715	606	700	735
" 4.....	637	752	674	670	720	607	709	745
" 5.....	632	760	695	666	731	612	706	751
" 6.....	623	770	694	668	721	618	711	754
" 7.....	626	754	693	684	731	628	716	763
" 8.....	635	767	712	694	748	629	732	773
" 9.....	626	764	708	697	741	638	740	766
" 10.....	634	760	694	683	720	637	729	770
" 11.....	622	754	694	678	719	639	728	766
" 12..... ...	643	766	702	684	721	644	737	762
" 13.....	644	760	696	690	730	640	730	757
" 14.....	648	784	686	695	739	651	731	775
" 15.....	645	764	678	685	735	650	730	755
" 16.....	658	763	711	701	752	653	746	784
" 17.....	643	773	706	691	755	664	752	776
" 18.....	649	782	708	699	752	655	755	775
" 19.....	652	785	719	697	763	657	755	794
" 20...	643	769	717	699	756	668	746	784
" 21.....	650	783	723	715	778	676	746	789
" 22.....	665	782	715	715	765	673	761	796
" 23.....	677	804	723	720	773	674	771	799
" 24.....	680	801	727	712	774	674	778	796
" 25.....	672	788	726	709	764	673	783	805
" 26.....	672	787	729	720	762	678	779	805
" 27.....	685	795	738	721	773	683	786	798
" 28...	685	816	741	734	779	685	780	819
" 29..... ..	673	788	719	712	785	683	773	801
" 30..... ..	677	795	737	715	781	681	768	793

TABLE SHOWING DAILY WEIGHTS OF HEIFERS—*Continued.*

Date.	1	2	3	4	5	6	7	8
	Period 2. Animals fed corn-fodder and ensilage from Burr's white corn.							
" 31	672	796	734	711	786	686	777	794
Feb. 1	681	813	732	732	790	692	790	812
" 2	682	793	750	720	787	694	784	825
" 3	686	798	718	733	790	692	786	820
" 4	691	784	746	722	780	691	794	815
" 5	689	821	739	702	782	691	787	802
" 6	697	803	738	738	788	696	792	810
" 7	700	809	756	744	806	708	801	825
" 8	698	813	753	744	791	709	797	822
" 9	707	826	758	753	803	704	795	822
" 10	718	822	762	753	793	705	806	820
" 11	722	848	761	742	791	705	797	846
" 12	722	833	752	742	778	705	803	829
" 13	717	836	762	745	811	728	814	835
" 14	728	837	758	749	819	724	824	838
" 15	723	827	758	743	812	723	807	837
" 16	725	837	757	747	820	723	813	861
" 17	723	834	763	761	810	720	828	850
" 18	740	842	761	761	822	730	825	843
" 19	741	831	771	760	828	719	828	845
" 20	738	838	764	766	831	716	809	871
" 21	733	821	768	765	841	714	822	854
" 22	748	842	762	772	838	733	829	863
" 23	738	843	787	769	842	721	837	845
" 24	746	851	783	769	837	730	830	870
" 25	753	854	780	769	844	733	839	888
" 26	736	854	789	773	840	727	838	868
" 27	757	848	785	773	843	735	830	865
" 28	756	848	790	776	830	743	834	862
March 1	750	857	785	765	818	750	835	860
" 2	750	857	791	773	840	750	840	884
March 3	763	863	790	777	843	749	835	872
" 4	760	867	795	776	845	752	836	866
" 5	753	875	804	792	847	745	850	882
" 6	769	883	804	785	841	745	847	881
" 7	745	853	805	752	835	735	838	848
" 8	767	881	808	740	854	725	843	828
" 9	775	880	808	774	851	739	851	861
" 10	773	885	800	780	848	756	850	871
	Period 3. Animals fed corn-fodder from Burr's white corn.							
" 11	765	877	800	780	835	733	828	881
" 12	753	882	802	784	841	734	823	866
" 13	766	888	802	783	842	728	826	860
" 14	773	893	799	790	846	747	823	870
" 15	778	895	815	795	841	737	831	881
" 16	762	892	808	786	837	756	833	892
" 17	765	894	820	798	833	755	834	893
" 18	778	890	827	802	830	757	832	899
" 19	761	883	831	800	821	756	831	897
" 20	765	890	827	805	823	760	835	895
" 21	780	887	822	797	825	760	832	899
" 22	775	883	833	790	828	761	812	901
" 23	760	887	824	792	822	761	832	882
" 24	776	887	819	796	827	771	835	893
" 25	781	883	831	797	831	767	839	891
" 26	780	884	825	795	825	771	839	854
" 27	774	895	830	796	827	766	833	868
" 28	761	874	814	790	821	753	821	869
" 29	782	900	827	811	834	774	840	900
" 30	782	898	835	814	834	775	846	907
" 31	792	906	834	818	843	782	852	901



Average Daily Weight of Heifers Fed Ensilage and Corn-Fodder.

TABLE SHOWING AVERAGE WEIGHTS OF HEIFERS FOR PERIODS NAMED.

Date.	1	2	3	4	5	6	7	8
January 2 to 6	631.6	758.2	674.8	677	719.8	611.2	704.5	743.4
January 9 to 13	633.8	760.8	698.8	686.4	726.2	639.6	732.8	764.2
January 26 to 30	678.4	796.2	732.8	720.4	776	682	777.2	803.2
March 6 to 10	765.8	876.4	805	766.2	845.8	740	845.8	857.8
March 27 to 31	778.2	894.6	828	805.8	831.8	770	838.4	889

During the first week of period 1, the four heifers fed corn-fodder gained 38 lb., while the four fed ensilage gained 82.5 lb. This is due to the change of stomach contents, as is shown by the comparative rate of gain after the first week. To make an accurate comparison of the rate of gain during period 1, it is necessary therefore to exclude the first week. Thus compared, the gain made by lot during the time the corn-fodder was fed stands, in pounds, as follows:

	Heifers fed corn-fodder.	Heifers fed ensilage.
Period 1 excluding 1st week	148	175.6
Period 2	285.6	251.
Periods 1 and 2, excluding 1st week	433.6	426.6
Gain per animal per day	1.94	1.90

In comparing the gain for the three periods, or the whole time of 12 weeks, the first week should be included, because from January 2d to 6th, and from March 27th to 31st both lots were fed alike.

The following table gives the gain, in pounds, per lot of each period, and the total gain for the three periods:

	Heifers fed corn-fodder.	Heifers fed ensilage. (during periods 1 and 2)
Period 1	186.2	259.5
Period 2	285.6	251.
Period 3	93.2	39.8
Periods 1, 2, and 3	565.	550.3
Gain per day per animal	1.68	1.64

POUNDS OF FOOD TO MAKE 100 POUNDS OF LIVE INCREASE.

The value of the food consumed, according to the standard here adopted, is determined by the number of pounds required to make a given increase. With the heifers fed corn-fodder, it required for every 100 lb. of increase 759 lb. of water-free substance. With the heifers fed ensilage during periods 1 and 2, it required for the three periods 817 lb. of water-free substance for every 100 lb. of increase.

From a practical standpoint, however, the difference was not so great, because there was a less percentage of the ensilage than of the corn-fodder left uneaten, and that left uneaten was so much wasted. Thus in period 2, in which the comparison can best be made on account of its longer duration and the more complete data, four heifers ate 80.6 per cent of the 8.14 lb. of water-free substance in the corn-fodder given daily, while four heifers ate 85.6 per cent of the 8.31 lb. of water-free substance in the ensilage given. In other words, the heifers fed ensilage ate more, but a part of what they ate would have been wasted if it had been cured corn-fodder.

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ANALYSES OF CORN-FODDER AND ENSILAGE MADE IN CONNECTION WITH THE FOREGOING EXPERIMENT.

From February 4, 1890, to March 12th, inclusive, duplicate samples of the cut corn-fodder, field-cured, and of the ensilage were taken each week. The samples were taken in duplicate because it was feared that, with our present fittings for drying only small samples, 2 to 3 lb. of corn-fodder and 5 to 7 lb. of ensilage might not be a sufficient quantity to represent fairly the 300 to 500 lb. from which the sample was taken. The sampling was done by filling tin pails with the feeds, the operator being seriously conscious how desirable it was that the contents of the pails fairly represented the feeding stuff. The average weight of the samples so taken was 2 lb. 11.9 oz. of the corn-fodder, and 7 lb. 2.3 oz. of the ensilage. After carefully recording the weight of the samples, they were cut so fine that no whole kernels of corn were left. None of the material was lost in the cutting. By recording the weights immediately after this cutting it was found that the corn-fodder did not lose in weight enough to be detected by the scales, which weighed to ½ oz.; but the ensilage lost by drying, on the average 1.5 per cent. of its weight. From this fine material a smaller sample of about 9 oz. was taken and its weight recorded. In the laboratory this was dried at 40° to 50° C., for about 24 hours, and while warm was ground so fine that it would pass through a sieve with openings .5 mm. in diameter. After grinding it was allowed to air-dry for about 12 hours and then weighed. From this an eight-ounce bottle was filled for the analyses.

The moisture in the air-dry sample was determined by drying 1 gram in a current of dry hydrogen at the temperature of boiling water. The fat (ether extract) was also determined in this same 1 gram from which the moisture had been expelled.

Analyses were made in the same way of samples of corn-fodder and ensilage taken at different times, three in the morning and three in the evening, from that not eaten by the animals.

The two following tables show the results of these analyses.

TABLE Showing Average of Analyses of Duplicate Samples of Corn-fodder and Ensilage as fed, Per Cents.

Sampled.	Corn-fodder.			Corn ensilage.		
	Dry matter.	Dry matter contains,		Dry matter.	Dry matter contains,	
		Nitrogen.	Ether extract.		Nitrogen.	Ether extract.
February 14	70.00	1.43	2.66	29.35	1.29	3.27
" 11	68.59	1.28	2.80	28.57	1.23	3.83
" 18	70.44	1.43	3.12	28.57	1.35	3.08
" 25	66.07	1.33	3.29	27.27	1.34	3.36
March 4.....	72.72	1.35	3.64	24.76	1.42	3.87
" 12.....	57.95	1.10	3.13	.....	.....	.....
Average	67.81	1.33	3.07	27.70	1.33	3.48

TABLE SHOWING ANALYSES OF SAMPLES OF REFUSED CORN-FODDER AND ENSILAGE, PER CENTS.

Sampled.	Corn-fodder (refused).			Ensilage (refused).		
	Dry matter.	Dry matter contains,		Dry matter.	Dry matter contains,	
		Nitrogen.	Ether extract.		Nitrogen.	Ether extract.
Feb. 17, p. m...	.....	.....	....	21.64	1.29	1.64
" 18, a. m. ..	.....	.....	....	23.63	1.32	1.44
" 25, p. m. ..	53.10	0.98	2.06	20.21	1.34	1.29
" 26, a. m. ..	57.20	0.99	2.21	21.23	1.34	1.73
March 11, p. m..	42.70	0.77	2.34	.....	.....	... .
" 12, a. m..	40.38	0.73	2.43	.....	.....	....
Average.....	48.55	0.87	2.26	21.68	1.32	1.53

Duplicate samples of ensilage and of corn-fodder were taken for analysis at five and six different dates respectively; also, samples of the refused corn-fodder and ensilage from the night and morning feed at two different dates. The analyses of the duplicates and of the morning and evening feeds showed *variations* as given below.

TABLE SHOWING THE AVERAGE WEIGHT OF SAMPLES TAKEN; THE MAXIMUM, MINIMUM, AND AVERAGE VARIATION IN PER CENTS IN THE COMPOSITION OF THE DUPLICATES AND OF THE NIGHT AND MORNING FEED REFUSED.

	Corn-fodder from shock.	Corn ensilage.	Corn-fodder, refused.	Corn ensilage refused.
Average wt. of sample taken.	2 lb. 11 oz.	7 lb. 2.3 oz.	1 lb. 12.1 oz.	5 lb. 2.4 oz.
Dry matter—				
Maximum variation.....	5.39	3.03	4.10	1.99
Minimum variation.....	1.02	1.45	2.32	1.02
Average variation.....	2.95	2.07	3.21	1.51
Nitrogen in dry matter—				
Maximum variation.....	0.19	0.14	0.04	0.03
Minimum variation.....	0.01	0.02	0.01	0 00
Average variation.....	0.08	0.06	0.02	0.01
Ether extract in dry matter—				
Maximum variation.....	0.44	0.65	0.15	0.44
Minimum variation.....	0.09	0.03	0.09	0.20
Average variation..	0.25	0.32	0.13	0.32

In the third annual report of the Wisconsin Station, p. 135, under the head "Errors of Analysis," Dr. Armsby makes the following statement:

"If a skilled marksman shoots a number of times in succession at a target, he finds that however carefully he may aim, no two balls strike the target exactly in the same place, and it is a matter of pure chance which particular ball, if any, hits the bull's-eye. In the same way, however carefully the chemist may make his determinations, it is a matter of pure chance which particular one, if any, comes out exactly right, or if any two determinations agree exactly with each other. But just as the skilled marksman will put all his balls within a certain distance of the bull's eye, depending upon the range, the quality of his weapon, and other condi-

tions, so the skillful chemist will bring his results very near the truth, the approximation depending on the nature of the method used."

The foregoing table shows that the per cent. of nitrogen and ether extract in the dry matter of duplicate samples was about the same, but the per cent. of *dry matter* varied considerably because of the small size of the samples taken for analyses.

The following table gives the composition of the feeding stuffs, average of all the analyses:

TABLE SHOWING COMPOSITION OF THE FEEDING STUFFS, PER CENTS.

	Water.	Ash.	Protein.*	Fiber.	Nitrogen-free extr'ct	Crude fat.
Corn-fodder as fed						
Fresh	32.19	3.49	5.76	13.56	42.91	2.09
Water-free		5.15	8.50	20	63.28	3.07
Corn ensilage as fed						
Fresh	72.30	1.54	2.30	6.02	16.88	0.96
Water-free		5.58	8.31	21.70	60.93	3.48
Fodder refused						
Fresh	51.65	3.96	2.95	17.28	23.07	1.09
Water-free		8.20	6.19	35.73	47.62	2.26
Ensilage refused						
Fresh	78.32	1.95	1.80	7.56	10.04	0 33
Water-free		9.03	8.37	34.86	46.21	1.53
Clover hay						
Fresh	18.23	6.34	12.93	25.10	34.68	2.72
Water-free		7.76	15.81	30.70	42.41	3.32
Crushed oats						
Fresh	13.32	3.32	11.48	9.73	57.22	4.93
Water-free		3.84	13.24	11.23	66.01	5.68

*Nitrogen x 6.25.

By drying the ensilage for analysis, the volatile acids are lost, and the figures of the table for per cent. of water include what is lost by drying at 100° C. in a current of hydrogen. A sample of fresh ensilage from another silo contained:

Volatile acid.....0.823 per cent.
Non-volatile acid.....1.211 per cent.

When the sample was ready for analysis, after drying at about 40° C. for 24 hours, grinding and air-drying, it was found to contain (calculated to fresh substance):

Volatile acid.....none.
Non-volatile acid.....0.955 per cent.

The figures for "crude fat" in the table also include acids soluble in ether.

The corn-fodder and ensilage not eaten or refused by the animals was principally the coarser stalks; comparing the analyses of water-free substance, shows that what was refused contains more water, ash, and crude fibre, but less nitrogen-free extract and crude fat than the original feeding stuff. The per cent. of protein is considerably less in the refused than in the original corn-fodder; while the ensilage left uneaten contained nearly the same amount as the original. This suggests that either the

nitrogeneous constituents are diffused through the ensilage more evenly than in the corn-fodder, or that the animals ate the ensilage without selecting or picking it over very much.

The relation of albuminoids to non-albuminoids is nearly the same in the refused as in the original *ensilage*, although quite different in the two kinds of corn-fodder.

TABLE SHOWING RELATION OF ALBUMINOIDS AND NON-ALBUMINOIDS IN THE DRY MATTER OF THE PROVENDER FED AND REFUSED.

The dry matter contains,	Corn-fodder. Per cent.	Corn ensilage. Per cent.	Corn-fodder refused Per cent.	Corn ensilage refused Per cent.	Clover hay. Per cent.	Crushed oats. Per cent.
Albuminoids.....	7.87	5.37	5	5	14.72	11.43
Non-albuminoids..	0.63	2.94	1.19	3.37	1.09	1.81

The following table shows the digestible nutrients and potential energy in 100 lb. of each of the feeding stuffs.

The digestion coëfficients used for the corn-fodder and corn ensilage are those given by Dr. H. P. Armsby, bulletin No. 9, Penn. Experiment Station. For clover hay and oats, the coëfficients are obtained from Wolff's Futterungslehre.

Digestion coëfficients used:

	Protein.	Fiber.	Nitrogen-free extract.	Fat
Corn-fodder.....	44	71	68	79
Corn ensilage.....	41	60	66	86
Clover hay.....	63	..	62	60
Crushed oats.....	72	..	67	80

The figures represent per cents. and are used as follows: The table on p. 317 gives the lb. of protein in 100 lb. of clover hay as 12.93. The digestion coëfficient of protein in clover hay is given as 63; that is, 63 per cent. of the 12.93 lb. (8.14 lb.) is digestible protein in every 100 lb. of the clover hay.

TABLE SHOWING DIGESTIBLE NUTRIENTS AND POTENTIAL ENERGY IN 100 POUNDS OF FEEDING STUFF NAMED.

	Corn-fodder.	Corn ensilage.	Corn-fodder refused	Corn ensilage refused	Clover hay.	Crushed oats.
Digestible protein, lb.....	2.53	0.94	1.29	0.73	8.14	8 26
Digestible crude fiber, lb.....	9.62	3.61	12.27	4.53	....	....
Digestible nitrogen free-ext., lb.....	29.18	10.68	15.69	16.61	37.07	44.85
Digestible fat (ether ext.), lb.....	1.65	0.82	0.86	0.28	1.63	3.94
Total digestible organic matter	42.98	16.05	30.11	12.15	46.84	57.05
Potential energy (calories).....	83,841	31,779	58,039	23,261	91,018	115,420
Nutritive ratio. ...	1:16	1:17	1:23	1:16	1:5	1:6.5

Although these estimates of nutrients and energy are crude, merely rough approximations, they are the best known to science at the present day, and give in figures a representation of the comparative value of feeding stuffs measured by a uniform mold of calculation.

The nutritive ratio represents the relation between the digestible nitrogenous and non-nitrogenous organic nutrients, or between the digestible protein and the remaining digestible organic matter. It is thus culculated: Counting the digestible protein as the first term of the ratio, the second term is found by multiplying the digestible fat by 2.25 (because 1 lb. of fat produces 2.25 times as much heat when burned as 1 lb. of the other organic nutrients) and by adding to this product the digestible crude fibre and nitrogen-free extract. In the foregoing table, each ratio has been reduced to a ratio whose first term is one.

The calories of potential energy show the "fuel values" of the digestible nutrients. One calorie is the quantity of heat necessary to raise the temperature of one kilogram* of water through one degree centigrade, and the energy, heat, or work represented by the calories in the foregoing table is obtained by multiplying the number of grams of digestible protein and carbohydrates (fiber and nitrogen-free extract) by 4.1 and the number of grams of digestible fat by 9.3, and taking the sum of the two products for the total calories contained in the digestible nutrients; because one gram of protein or carbohydrates, if its potential energy is converted into heat, will raise the temperature of 1 kilogram of water through 4.1 degrees centigrade, and 1 gram of fat will raise the temperature of the same amount of water through 9.3 degrees centigrade.

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VALUE OF PASTURE, AND OF GRAIN RATION WITH PASTURE, FOR YOUNG CATTLE.

Experiment No. 27.

The following pages contain a report of experiments tried in 1888 and 1889 to ascertain:

1. The feeding value, for young cattle, of pasture.
2. The value of a grain ration for young cattle on pasture.

Similar experiments are to be tried in 1890, and full details are not here published. In a more than usual degree the results are suggestive rather than conclusive. The questions to be solved are more complex than appears at first statement. Thus, evidently cattle with a grain ration will eat less grass; but how much less? The droppings of the grain-fed cattle will be more valuable as manure; but how much more? A better result will be secured if hogs follow the grain-fed cattle; but in what number? Aside from such questions as these, correct answers to which can-

*One kilogram equals 2.2 + pounds.

not be given in advance of repeated experiments, the obvious difficulties in making the results in one season apply to a season of a different character, or those from one pasture apply to a different pasture, make the results of two years' trials only suggestive.

The trials were made on the University lands—good, dark-colored prairie soil. Five acres of blue-grass pasture, with some white clover, was selected and divided into plats of two and three acres each; much alike, except that a small portion of the three-acre plat had some orchard grass and a little timothy in it. These plats were used both years. In 1889 there was also used ten acres of a fair average blue-grass pasture. All the land had been in pasture for ten years.

In April, 1888, eight young steers were selected, of which the exact age and breeding were known in but a single case. Probably each had some Shorthorn blood, and the age varied from eight to fourteen months. They were not so uniform nor so good as would have been desirable, but were such as could be obtained conveniently. They were divided into two lots of four each as nearly equal in weight and quality as possible.

April 18th, each lot was placed in a dry lot, and for four weeks they were fed all they would readily eat of hay and a mixture of corn, 60 lb., oats, 40 lb.; bran, 25 lb.

May 14th, one lot was put into the three-acre grass plat and received no other food. The other was put into the two-acre plat and, in addition to the grass, was fed the grain ration twice daily.

The following notes of the condition of the grass were made: June 11th, blue-grass headed and well covered the pastures. June 25th, culms and heads of the blue-grass dead. July 10th, heads and culms of the blue-grass disappearing somewhat; fresh grass growing abundantly. No material difference was noted in quality or quantity of the grass in the two-plats. July 23rd, much of the old blue-grass remaining. One-fourth to one-third of each pasture cropped closely. More white clover in the two- than in the three-acre plat. Up to this date the pastures have apparently contained more feed than was needed by the steers.

October 29th, the steers were taken from the pasture and were thereafter fed hay and grain, and ran in a small grass lot during the day. January 21, 1889, corn ensilage was substituted for the grain. For two weeks all the hay the steers would eat was given them. From Feb. 4th to March 18th, the hay given was limited. From the latter date to April 29th, grain was substituted for ensilage. At this date the eight steers were placed on ten acres of pasture, receiving no other food until September 25th. From this date to November 25th they were fed ear corn and were allowed to remain on the same pasture. The corn was husked as needed. Fifty pounds from each load was hung up to dry. December 11th, the sample lots of corn were shelled and the weight of the shelled corn taken. From this the quantity of air-dry corn fed was calculated.

The weight of each lot of steers at given dates, and the quantity of hay, grain, or ensilage eaten in each period are given in the accompany-

ing tables. The weighings were in the morning, after feeding, but before watering. The steers were weighed separately. The weighings here reported were at intervals of two weeks with one or two exceptions, which will be readily noted.

TABLE SHOWING WEIGHTS AND GAINS OF ANIMALS, AND WEIGHTS OF FEEDING STUFFS FOR PERIODS GIVEN.

Dates. 1888-89.	Lot 1.				Lot 2.			
	W'ght	Gain.	Grain.	Hay.	W'ght	Gain.	Grain.	Hay.
April 18	2,405	.....	*	*	2,210	.....	*	*
April 30	2,500	95	*	*	2,360	150	*	*
May 14	2,535	35	.....	.....	2,395	35	.....	.....
May 28	2,665	130	.....	.....	2,575	180	432	.....
June 11	2,735	70	.....	.....	2,665	90	341	.....
June 25	2,935	200	.....	.....	2,760	95	280	.....
July 10	2,925	-10	.....	.....	2,845	85	251	.....
July 23	2,990	65	.....	.....	2,840	-5	209	.....
August 6	2,980	-10	.....	.....	2,880	40	258	.....
August 20	3,005	25	.....	.....	2,925	45	265	.....
September 3	3,175	170	.....	.....	3,045	120	259	.....
September 17	3,134	-41	.....	.....	3,101	56	245	.....
October 1	3,274	140	.....	.....	3,153	52	324	.....
October 15	3,183	-91	.....	.....	3,306	153	364	.....
October 29	3,129	-54	.....	.....	3,275	-31	305	.....
November 12	3,170	41	351	165	3,310	35	400	170
November 26	3,215	45	421	388	3,315	5	441	392
December 10	3,380	165	502	687	3,450	135	492	683
December 24	3,427	47	560	708	3,523	73	566	701
January 7	3,500	73	733	617	3,579	56	713	654
January 21	3,523	23	630	625	3,575	-4	656	675
Ensilage was fed in Place of Grain from Feb. 4th to March 18th.								
February 4	3,562	39	1,234	525	3,625	50	1,219	575
February 18	3,510	-52	1,887	225	3,585	-40	2,072	225
March 4	3,560	50	1,892	264	3,643	58	2,228	264
March 18	3,599	-39	1,765	245	3,653	10	2,129	245
April 1	3,645	46	719	430	3,733	80	731	430
April 15	3,686	41	520	510	3,791	58	719	520
April 29	3,729	43	405	405	3,813	22	755	405
May 13	3,993	264	.....	.....	4,061	248	.....	.....
May 27	4,043	50	.....	.....	4,110	49	.....	.....
June 10	4,143	100	.....	.....	4,156	46	.....	.....
June 24	4,299	156	.....	.....	4,373	217	.....	.....
July 8	4,204	-95	.....	.....	4,274	-99	.....	.....
July 22	4,214	10	.....	.....	4,292	18	.....	.....
August 5	4,291	77	.....	.....	4,366	74	.....	.....
August 19	4,411	120	.....	.....	4,511	145	.....	.....
September 2	4,378	-33	.....	.....	4,430	-81	.....	.....
September 23	4,430	52	.....	.....	4,494	64	.....	.....
October 14	4,500	70	†	.....	4,604	110	†	.....
October 28	4,722	222	†	.....	4,825	221	†	.....
November 11	4,798	76	†	.....	4,849	24	†	.....
November 25	4,832	34	†	.....	4,847	-2	†	.....

* From April 18th to May 14th, both lots were fed together 1,800 lb. of grain and 1,498 lb. of hay.

† From Sept. 25th to Oct. 14th, both lots were fed together ear corn the equivalent of 1,622 lb. of air-dry shelled corn; Oct. 14th to 28th, 1,752 lb.; Oct. 28th to Nov. 11th, 1,951 lb.; Nov. 11th to 25th, 1,802 lb.

May 20, 1889, six steers were selected. One was known to be pure Shorthorn; the others were grade Shorthorns, but exact breeding and age were unknown. One was apparently under one year old; one 14 months; the others probably 18 to 20 months. They were divided into two lots of three, and placed on the pasture plats used in 1888. Commencing May 27th, lot 4 was fed shelled corn in addition to the pasture; lot 3 had nothing but the grass.

June 10th, two Poland-China pigs were put into the two-acre plat with lot 4, receiving no other food than the grass and offal from the steers. These pigs weighed 285.5 lb. Until Sept. 24th, at which time ear corn was substituted for shelled corn, they had gained 129.5 lb. Until Oct. 28th, at which time the growth of grass may be assumed to have mainly ceased, the gain had been 163 lb., and until Nov. 25th, when the experiment ceased, the total gain had been 195 lb.

From Sept. 25th, to Nov. 25th, each lot was fed corn in the ear, husked as needed. A sample of each load was dried, and from the weight of the shelled corn of these sample lots the quantity of air-dry corn eaten by each lot of steers was calculated.

The weights of each lot of steers at dates named, and the quantity of grain eaten are given in the accompanying table. As in the preceeding experiment, the weighings were in the morning, after feeding, but before watering.

TABLE SHOWING WEIGHTS AND GAINS OF ANIMALS, AND WEIGHTS OF CORN, FOR PERIODS GIVEN.

Dates. 1889.	Lot 1.			Lot 2.		
	Weight.	Gain.	Corn.	Weight.	Gain.	Corn.
May 20	2,231	.....	.....	2,276	.....	.....
May 27	2,344	113	.....	2,386	110	.....
June 10	2,440	96	.....	2,435	49	225
June 24	2,514	74	.....	2,459	24	324
July 8	2,610	96	.....	2,465	6	300
July 22	2,598	−12	.....	2,529	64	356
August 5	2,642	44	.....	2,638	109	480
August 19	2,746	104	.....	2,705	67	469
September 2	2,745	−1	.....	2,761	56	349
September 24	2,848	103	.....	3,020	259	660
October 14	2,861	13	*801	3,046	26	*801
October 28	2,951	90	507	3,167	121	619
November 11	2,999	48	695	3,184	17	721
November 25	3,010	11	551	3,187	3	619

*From this date the corn was ear corn equivalent to the number of pounds of air-dry shelled corn named.

GAIN FROM PASTURE ONLY.

Study of the tables shows remarkable variations in the rate of gain of the steers, especially those having no other food than grass. Thus, the four steers on three acres of pasture in 1888, from May 14th to June 25th, six weeks, gained 390 lb.; for the next eight weeks, only 71 lb.; and for the next six weeks. 269 lb.; while during the next four weeks, Oct. 1st to Oct. 29th, they lost 145 lb.

In 1889, the three steers on the same three acres made a gain of 104 lb., in the two weeks from Aug. 5th to Aug. 19th, and lost 1 lb. during the next two weeks.

In 1889, the eight two-year-old steers on ten acres of pasture gained 1,130 lb. in eight weeks, from April 29th to June 24th, and only 252 lb. in the next 13 weeks.

Some reasons for these variations are obvious, but it is difficult to explain all of them. Except during October, 1888, the pastures did not appear to be grazed unusually short at any time. In the earlier part of each season the supply of grass was, apparently, more than the cattle needed. It seems evident, however, they were too heavily stocked, taking the seasons as a whole. In no case was there a satisfactory gain per animal for the summer's grazing. In 1888, the four steers made an average gain of 185 lb. from May 14th to Oct. 1st. In 1889, eight steers made an average gain of 173 lb. from April 29th to Sept. 23d, and three yearling steers made an average gain of 206 lb. from May 20th to Sept. 24th. Fractions of a pound are not given above. The gain in the last case may be considered passably good, but is below what is desirable.

In trials in former years on the University farms with several lots of yearling steers, the following gains were made in the six months from May 1st to Nov. 1st, there being in one or two cases a variation from this time of two or three days: Four steers, average gain, 332 lb.; 10 steers, average gain, 285 lb.; 2 steers, average gain, 440 lb.; eight steers, 223 lb.—this last from April 25th to Sept. 1st. Of two-year-old steers, during six months, seven made an average gain of 466 lb.; eight, of 380 lb.; four, of 406 lb.

The gains per acre of grass-land were more satisfactory than the gains per animal. The three-acre pasture, in 1888, supported four steers with an average aggregate weight of 2,904 lb. which made a gain of 739 lb., or 246 lb. per acre from May 14th to Oct. 1st. The same pasture, in 1889, supported three steers, with an average aggregate weight of 2,540 lb. which made a gain of 617 lb. or 206 lb. per acre from May 20th to Sept. 24th. The ten-acre pasture, in 1889, supported eight steers with an average aggregate weight of 8,233 lb. which made a gain of 1,382 lb., 138 lb. per acre, from April 29th to Sept. 24th.

With cattle selling at any reasonable price any of these gains would give a good return for the use of the land; especially as pasturage is one of the least exhaustive uses to which we can put our lands.

The results of pasturage in October, 1888, are not considered here, as it is evident there was not sufficient food for the cattle. After Sept. 24, 1889, all the cattle were fed grain.

Effect of Grain Ration with Grass.

It was assumed that the steers receiving a liberal grain ration might safely have the acreage of pasture reduced one-third, and the appearance of the two plats used indicated that this assumption was fairly correct.

The steers fed grain made a more uniform gain than those on pasture alone, but the variations in equal periods were sufficiently noticeable. In 1888, the four steers on the two acres of grass, from May 14th to Oct. 1st, ate 2,864 lb. of the mixture of corn, oats, and bran, an average of 716 lb. each, and made a gain of 758 lb., or 189.5 lb. each. This was a gain only 39 lb. larger than that made by the four steers on the three acres of grass without grain. That is, there was a gain of 39 lb. in weight, a saving of one acre of pasturage, and an undetermined increase in the value of the manure to offset the value of 2,864 lb. grain fed and the increase of labor made necessary by this feeding. Evidently the grain was fed at a loss in this case.

In 1889, the three steers on the same two acres of pasture, ate 3,163 lb. of corn and made a gain of 634 lb., from May 27th, to Sept. 24th, or 130 lb. more than the gain made during the same period by the three steers on three acres of pasture. The two pigs with the grain fed steers increased 129.5 lb. during the period. With beef and pork selling at average prices, this increased gain and the rental value of one acre of land would about equal value of the corn fed.

No considerable difference was found in the rate of gain in the two lots of steers in the autumn months when both were fed grain. In two cases the advantage was with the lots not having had grain during the summer; in the third case the steers fed grain during the summer made slightly larger gain in autumn than those which had pasture only.

It was easily noticeable in the late autumn and following spring, that the three-acre was better than the two-acre pasture One reason evidently was that, when grain was given both lots of steers, they would eat about equal quantites of grass, the three-acre plat thus having the advantage.

Gain from Grain and Hay

From April 18 to May 14, 1888, the eight steers ate 1,800 lb. of the mixed grain ration and 1,498 lb. of hay, and gained 315 lb. From October 29th to Jan. 21st, they ate 6,465 lb. of grain and 6,365 lb. of hay, and gained 694 lb. From March 18th to April 29th, they ate 4,409 lb. of grain and 2,700 lb. of hay, making a gain of 310 lb.

From Jan. 1st to March 18th, corn ensilage was substituted for the mixed grain ration. During this period they ate 15,218 lb. of ensilage, and 2,568 lb. of hay and made gain of 154 lb.

For the first period of 26 days, the average gain per day for each steer was 1.5 lb.; the average daily ration being about nine lb. of grain and seven lb. of hay. For the second period of 84 days, the average gain was a little over one pound per day, with ration of 9.6 lb. grain, and 9.5 lb. hay. For the last period of 42 days the average gain was a little over one-tenth of a pound, with a daily ration of almost exactly 13 lb. of grain and 8 lb. of hay. During the 56 days when ensilage was substituted for the grain ration, the daily gain was a trifle over one-third of a pound per day with ration of 34 lb. of ensilage and 5.75 lb. of hay.

From Sept. 24 to Nov. 29, 1889, all the steers were fed ear corn on the pastures. The results were surprising. In no case was there a large gain made, and, although the weather was not cold at any time, nor unusually unpleasant, the gains during the last four weeks were especially small.

From Sept. 23d to Oct. 28th, each of eight steers made an average daily gain of 2.2 lb., eating the equivalent of 12 lb. air-dry shelled corn per day. From Oct. 28th to Nov. 25th, the average daily gain was only about six-tenths of a pound, with the equivalent of 16.7 lb. of corn eaten. The six younger steers during the first period made an average daily gain of about 1.2 lb. each, eating 13 lb. of corn. During the second period the average daily gain was not quite four-tenths of a pound, with a ration of 12 lb. of corn each per day.

In feeding in a similar manner on the University farms, lots of steers have frequently made average daily gains of three pounds each during September and two and three-fourths pounds during October. As the weather grew colder the rate of gain always decreased, but rarely, if ever, to so low a point as noted above, unless in case of extreme cold or storms.

Suggested Conclusions.

The results from two years' trials indicate that a grain ration to young steers on good pasture is not usually profitable. The value of the increase in weight by the grain-fed steers over that by those having grass only, will rarely repay the cost of food and labor. The increased value of the animals from earlier maturity and better quality may make the grain feeding profitable.

Especially if the grain given be unground, is it essential to have pigs follow the cattle, if a profit is to be had.

To secure the greatest gains per animal the pastures must not be fully stocked. To secure the largest gain per acre they should be fully stocked.

An acre of good grass may be expected to support a steer weighing from 800 to 1,000 lb., and enable it to make a moderate gain during the summer.

The rate of growth of cattle, either on grass alone or with an added grain ration, is very irregular, being especially checked by either drouth or excessive rains, extreme heat or cold storms.

The addition of grain or other food to the pasturage before the grass fails in the autumn is clearly advisable.

The acreage of pasturage may probably be safely decreased one-third, if the steers be given a full grain ration.

It is doubtful if, at present, in most parts of Illinois, cattle can be maintained or an increase of weight be secured at so low a cost in any other way as by allowing them to get all their food during the best of the grazing season from good pastures, fully but not over stocked.

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Agriculturist.

EXPERIMENTS IN PROGRESS.

In the list below are given by number and title the experiments which are now in hand. Some of them, as will be seen, are of such a nature that they will run through two, three, or even many years; and others we are repeating for the second or third time. Reports have been published upon certain of the experiments, and in the last column of the table are the numbers of the bulletins in which such reports may be found.

LIST OF EXPERIMENTS IN PROGRESS.

No.	Class and title of experiment.	Reported in bulletins
	Field Experiments.	
1	Corn, testing varieties	Nos. 4 and 8
2	Corn, testing varieties for ensilage	No. 4
3	Corn, time of planting	Nos. 4 and 8
4	Corn, depth of planting	"
5	Corn, thickness of planting	"
6	Corn, planting in hills and drills	No. 4
8	Corn, frequency of cultivation	Nos. 4 and 8
9	Corn, depth of cultivation	"
10	Corn, effect of root-pruning	"
11	Corn, effect of fertilizers—large plats [In part at Flora]	"
12	Oats, quantity of seed per acre	Nos. 3 and 7
13	Oats, compact or loose seed bed	"
4	Oats, time of sowing	"
5	Oats, depth of sowing	"
16	Grasses, comparison of varieties	
17	Clovers, comparison of varieties	
18	Grasses and clovers sown with or without grain	
19	Grasses, field tests of varieties	
20	Clovers, field tests of varieties	
21	Grasses and clovers, field tests of mixtures	
22	Weeds, number and kinds on given areas	
23	Rotation, University experiments continued	
24	Fertilizers, comparison of, on corn—small plats	Nos. 4 and 8
54	Corn, root-growth	"
62	Wheat, effect of fertilizers	
63	Wheat, methods of soil preparation	
65	Wheat, quantity of seed per acre	
66	Wheat, time of sowing	
67	Wheat, depth of sowing	
68	Wheat, its relation to chess	
69	Wheat, effect of fertilizers upon. [Experiments at Flora, Odin, and Farina]	
71	Corn-fodder, effect of ripeness	
84	Oats, testing varieties	No. 7
85	Oats, effect of sowing spring wheat with	
86	Fertilizers, effect on grass-lands	
88	Beets, testing varieties	
89	Corn, cross fertilization of	
90	Corn, rate of growth	
103	Comparative yield of corn planted with and without pumpkins, and of pumpkins planted with and without corn	

LIST—*Continued.*

No.	Class and title of experiment.	Reported in bulletins
	Feeding Experiments.	
27	Cost of production of young cattle	No. 9
28	Cost of production of young colts	
29	Cost of production of young calves	
59	Cost of production of young heifers	
60	Pigs, comparison between corn, grass, and corn and grass in feeding	
100	Pigs, comparative value of corn and beets, and corn in feeding	
	Tree Culture.	
31	Orchard, soil cultivation and management	
32	Orchard, soil fertilization	
33	Apples, testing new varieties by planting	
34	Apples, testing new varieties by top-grafting	
35	Apples, testing hardiness of root-grafted and double-worked trees	
36	Pears, testing new varieties	
37	Plums, testing new varieties	
38	Cherries, testing new varieties	
39	Forest trees, growing of	
78	Testing time and methods of transplanting trees	
79	Testing and improving native fruits	
80	Testing the effects of stock and cion upon each other	
91	Peach trees, winter protection of	
101	Trees, protection of trunks	
102	Trees, protection from mice, rabbits, and insects	
	Vine Culture.	
40	Grapes, testing new varieties	
41	Grapes, methods of training	
42	Grapes, soil treatment	
	Small Fruit Culture.	
43	Blackberries, testing varieties	
44	Raspberries, testing varieties	
45	Strawberries, testing varieties	
51	Strawberries, raising seedlings	
52	Raspberries, soil management	
	Gardening.	
48	Beans, testing varieties	
49	Sweet corn, testing varieties	Nos. 4 and 8
56	Potatoes, investigation of scab	
104	Cucurbitaceous plants, tests of, except melons	
	Tree and Vine Culture.	
55	Fungicides, use of	
57	Insecticides, use of	
	Miscellaneous.	
73	Record of soil temperature	
75	Soil moisture, evaporation of water from the surface of water of uncultivated soil, of cultivated soil, of a corn plant, and of grass	
76	Meterological record from August 17, 1888	
77	Biology of ensilage	No. 7
92	Canada thistles, extermination of. [At Mattoon]	
93	Fruits, production of new varieties from seeds	
94	Vitality of timothy, blue grass, and red-top seeds tested	
97	Vitality of seeds tested	
105	Investigation of a bacterial disease of corn	No. 6
106	Investigation of milk tests	No. 9

All communications intended for the Station should be addressed, not to any person, but to the

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The bulletins of the Experiment Station will be sent free of all charges to persons engaged in farming who may request that they be sent.

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